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THE LATEST EAST RIVER BRIDGE SCHEME is embodied in the bill introduced into the New York Legislature by Assemblyman Brennan. This bill names a commission of six men, who, together with the Mayor and the Controller of New York, are to undertake the erection of a suspension bridge across the East River adapted for the use of both surface and elevated railways. The bridge would be located somewhere between Fulton Ferry and the Navy Yard, in Brooklyn, and corresponding streets on the New York side. After completion the bridge would be handed over to the Department of Bridges of New York. The bill further gives the commission authority to utilize all papers, plans, etc., in possession of the city or of other corporations bearing upon the project for a bridge at this point. A counter-bill has been introduced by Senator Grady giving the City of New York the authority to build bridges over the East River, to acquire all lands under water necessary or suitable for these bridges, and to condemn land for approaches, etc. In short, to acquire all rights for bridge building which might hereafter be appropriated by commissioners for this purpose, and to prevent special legislation.

A RAILWAY TUNNEL UNDER THE EAST RIVER forms a part of the project covered by a bill introduced in the New York Legislature by the Long Island Railway Co. A bill for the depression of the tracks of this company on Atlantic Ave., Brooklyn, was passed at the last session. The present bill asks for power to operate a street surface line above these depressed tracks. The whole plan, however, is said to include a railway tunnel under the East River, from the terminus of Atlantic Ave. to Maiden Lane, New York, and an underground railway from the last point as far uptown as 42d St., at least. The avowed purpose is to provide railway facilities from 42d St., through Brooklyn to Montauk Point. The bill covering the latter part of the scheme is yet to be introduced, as the efforts to obtain a franchise for the river tunnel from New York city were interfered with by the provisions of the new charter. The railway company owns in fee the middle portion of Atlantic Ave. and claims the right to operate a surface railway after its steam tracks have been depressed. The bill introduced is intended to confirm this right.

THE NATIONAL HUDSON BRIDGE CO. is asking Congress for an act of incorporation and authority to construct a bridge across the Hudson River, at New York city, with a single span between bulkhead lines and 150 ft. clear height at the middle. The principal incorporators are Frank H. Lord, Ralph T. Rokeby and Gustave C. Henry. According to Mr. Henry this is the result of some dissatisfaction among the stockholders of the New York and New Jersey Bridge Co., who believe it is better to start all over again and secure an extension of time. Beyond the time limit, the bill is essentially the same as for the older company.

THE 68TH ST. WATER TUNNEL at Chicago, Ill., is again the source of trouble, in the shape of another controversy between the city and the contractors. In building the new 7-ft. tunnel (Eng. News, Sept. 23, 1897), an old river bed of soft material was encountered, and after the water had gotten in, the line of the tunnel was bowed out for about 1,500 ft. in order to strike this bed where it was narrower. On reaching a point where the new location might be expected to strike the treacherous material, the city engineer ordered an air lock to be built and the compressed air system to be employed. The contractors, Ross & Ross, however, claimed that their work was finished at this point, and after some controversy they secured a new contract at an additional price. Recently the contractors stopped work, within about 800 ft. of the connection with the existing section of the tunnel on the original location at the end of the bowed section. They claimed that their contract was ended, and did not include making the connection, and hinted at a prompt removal of their plant unless a new contract was made. Acting on the advice of the law department, the City Engineer, Mr. John Ericsson, took possession of the plant, and is organizing a force to carry on the work.

A DANGEROUS FIRE occurred Jan. 16 at the head of the Keith St. shaft of the new water-works tunnel at Chicago. The building used by the contractors, Weir & McKechney, caught fire about 10 p. m., and as dynamite was stored in one room there was considerable excitement in the neighborhood. Men at the shaft house ran to the building when they heard the shout of the watchmen and carried out all the boxes without accident.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Atlantic Coast Line about 80 miles west of Charleston, S. C., Jan. 21. According to reports, "The New York—Florida Special" and No. 52, a local from Charleston, collided head on, killing both firemen and slightly injuring several trainmen and passengers. The accident is attributed to a confusion of train orders, which allowed the special to crash into the local before it could reach the siding.

A LOCOMOTIVE BOILER EXPLODED in the round house of the Chicago & North Western Ry., at Madison, Wis., Jan. 24, killing three men, fatally injuring two others and wrecking three engines and the building. The engine was about ready to leave the house to pull a passenger train when the top part of the boiler blew off, going some 500 ft. through the air.

A BRIDGE CAISSON CAPSIZED at Gray's Ferry, on the Schuylkill River, in Philadelphia, on Jan. 21. The new bridge being built there will have five caisson piers, says the Philadelphia "Ledger." The wooden caisson which capsized was 16 ft. wide, 56 ft. long and 49 ft. high, and it contained 700 cu. yds. of concrete as ballast. At the site of this pier there is 35 ft. of soft mud; and, according to the description, the caisson was being sunk by excavating the mud from the ends and filling with concrete. About 15 ft. of the mud had been removed, when the caisson, from some unexplained cause, began to totter and finally fell over on its side. The contractors, the Jutta & Foley Co., of Pittsburg, Pa., have not yet decided whether they will build a new caisson or attempt to raise the sunken one. The sunken caisson, with its concrete filling, is said to weigh about 2,000 tons.

THE INJURIES TO THE POE LOCK at Sault Ste. Marie, Mich., which have been reported in the newspapers, prove to be much less serious than the press despatches indicated. In a letter dated Jan. 18, Lieut. J. F. McIndoe, U. S. Engineer Corps, who has made an examination of the lock floor, says:

The injuries to the lock are not at all of a serious nature. No injury whatever has been done the lock floor, but a few planks, probably not more than a dozen, have been lifted from the floors of the culverts. A few bolts will repair the damage. The walls between the culverts consist of timbers drift-bolted together and the lock floor is held down by long rods wedge-bolted into the rock beneath. As originally designed these rods were to pass close along the face of the culvert walls, but for structural reasons it was found necessary to leave a space of about 3 ins. between rods and walls. (See Section A-B, Inset, Eng. News, Sept. 26, 1895.) When the lock was pumped out it was found that for a distance of about 175 ft. the pressure of the water, due to a valve being opened on only one side of the wall for a short time, had caused a lateral movement of the walls back and forth until the rods had become badly bent and some of them had been torn loose from their hold in the bed rock. It is probable, too, that many of the drift bolts in the walls are broken, as some of the timbers show evidence of movement one upon the other. It is proposed to repair the damage and to prevent its recurrence by strapping the walls vertically at intervals and by passing through these straps, from one lock wall to the other, rods in sections coupled with sleeve and lock nuts. It is estimated that the repairs will cost at the outside about $2,000 for material and labor.

A full description of the Poe Lock was published in our issues of Sept. 26 and Oct. 10, 17 and 31, 1895.

A STEEL FLOATING DOCK, to be built by a private corporation at a cost of $1,500,000 and made large enough for the heaviest battleships, is the purport of a proposition made to the House Naval Committee. The government, in return for the use of this dock for 100 days in the year, is asked to guarantee 6% interest on the above amount for 20 years. In case of war the government would have sole use of the dock. Mr. L. A. Downey, the president of the dock company, says the dock contemplated would be 550 ft. long and have a capacity of 15,000 tons. It would be moored somewhere between Owl's Head and Red Hook Point, near Brooklyn. The Newport News Shipbuilding Co. is also said to be ready to construct a dry-dock of the largest capacity and to be governed by the Navy Department as to character, size and materials. Completion is promised in one year after authority is granted.

A HARBOR OF REFUGE, at Absecom Inlet, N. J., is projected by the government, and Major C. W. Raymond, Engineer Corps U. S. A., has made an extended report upon it. The plan proposes a jetty of rubble-stone 7,422 ft. long, extending to low water and topped with heavy stone to 4 ft. above the level of mean high water. This one jetty would establish the channel in a permanent position and maintain about 10 ft. at mean low water, a depth sufficient for the present purposes of local commerce. The estimated cost of this jetty is $500,000.

BILGE KEELS are being adopted on the transatlantic steamers of several lines. They are being fitted to old steamers as well as to new ones. It is claimed that they prevent excessive rolling without decreasing the speed of the vessel.

FOREIGN POSTAL TRANSMISSION is surprisingly rapid nowadays. A letter sent to Vienna from an office in New York city was despatched by the steamer sailing at 10 a.m. on Wednesday, Jan. 5, and a cablegram reply was received at 10:45 a.m. Thursday, Jan. 13. The route of the letter, with distances, was as follows: New York to Southampton, 3,050 miles; by rail to London, 80 miles; by rail and channel steamer to Paris, 238 miles; by rail, Paris to Vienna, 735 miles, a total of 4,203 miles.

55 MILES IN 47 MINUTES while hauling a train made up of 8 heavy cars is the record made by a Schenectady locomotive running between Columbus, O., and Xenia, O., on the Pittsburg, Cincinnati, Chicago & St. Louis Ry. The actual time was 56 minutes but this included three stops, one crossing slow-down and a delay of four minutes at London, making a total of 9 minutes. Deducting this, the time given above is obtained. Put in another way this means a speed of about 73 miles per hour.

AN OLD BAGGAGE CAR FITTED WITH ELECTRIC motors was tested on the electric railway at Atlantic City, N. J., Jan. 13, with the idea of dispensing with the use of steam locomotives on Atlantic Ave. Motors aggregating 160 HP. were placed on the trucks of the car which was used to haul four coal cars, weighing some 170 tons. During the test a speed of about 20 miles per hour was attained and the experiment was considered entirely successful. Wm. K. McAllister and W. Elmer, both of the Pennsylvania R. R., had charge of the work.

AN ELECTRIC RAILWAY MOTOR DECISION has just been rendered by Judge Wheeler, of the United States Circuit Court, which is of considerable interest to electric railway men. According to this the patent covering the method of supporting motors on cars so that the jar will not injure the motors, and at present owned by the General Electric and Westinghouse companies, is sustained. And an injunction against using this form of suspension has been issued against the Union Railway Co., New York city, and the Walker Co., Cleveland, O.

THE ENGLISH STRIKE IN THE ENGINEERING trades, which was inaugurated on July 12, 1897, seems now to have resulted in a complete victory for the employers. According to the news reports from England, the men have been returning as individuals for some time, and on Jan. 23 the Executive Committee of the strikers officially advised the men to accept the employers' terms. The chief demands made by the men were for a week of 48 working hours, and, more vital still to the employer, the practical control by the trades unions of the amount of work done by individual workmen and the manner of operating machinery. This strike has affected over 200,000 persons, and has caused the loss of about $75,000,000 to the nation, as estimated by the English Labor Department. Of this total about $15,000,000 is represented by direct loss in wages and in money paid out by trades unions in supporting the strike. The contest has been a bitter one, but the employers were fighting German and American competition as well as the demands of their workmen, and they could not afford to yield even to some of the more just demands of the men. The unions, on their part, refused to accept a proposition made that would still have left to them the right of collective bargaining on the question of the rate of wages. Now, their defeat is complete and crushing; and legitimate organization among workingmen in England is in a worse way than for years past.

RAPID DOUBLE FILTRATION AND AERATION OF SEWAGE AT READING, PA.

An interesting plant for treating sewage at a very high rate by means of screening or straining through coke, followed by double filtration combined with aeration was put in operation at Reading, Pa., about Oct. 1, 1896. The high rate of treatment will be appreciated by those familiar with modern practice in sewage disposal when it is stated that two superimposed filter beds, with the small area of only 12,500 sq. ft. each, are designed to filter 5,000,000 gallons of coke-screened sewage per day, on the continuous plan, the filtration being supplemented by such aeration as can be effected by spreading the sewage on the upper bed and dropping it 8 or 10 ft. from the upper to the lower bed. This is at the rate of 400 gallons per sq. ft. per day, or 17,424,000 per acre, through each bed, with no allowance for compartments out of use for cleaning, repairs and renewals. Taking into account the double filtration, the rate is 8,712,000 gallons per acre per day. The generally accepted rate for intermittent filtration under the most favorable conditions is 100,000 gallons per acre per day.

By placing one bed directly over the other the amount of land required is cut in half, but, of course, at the expense of the necessary supports for the upper bed. It is claimed in addition that the aeration effected by giving the air free access to the beds and by dropping the sewage from one bed to the other plays an important part in making possible the high rate of filtration.

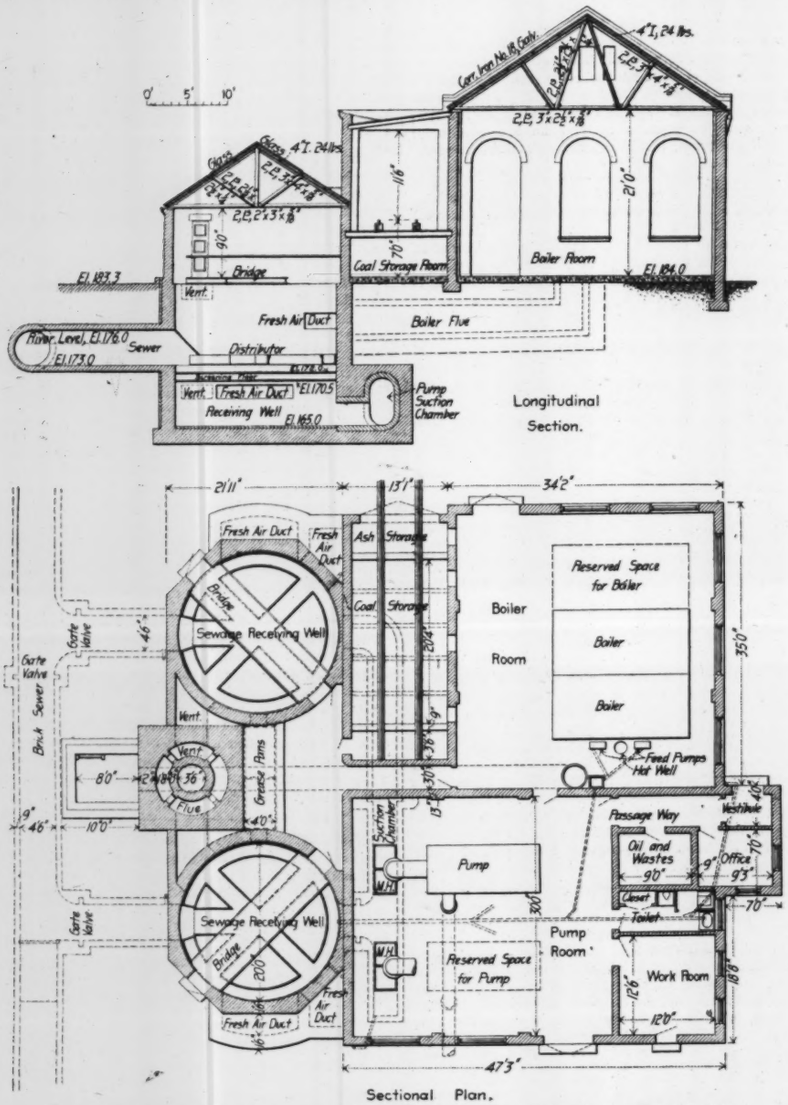


FIG. 1.—PLAN AND CROSS-SECTION OF SEWAGE PUMPING STATION AT READING, PA.
Pennsylvania Sanitation Co., Philadelphia, Contractor. John Jerome Deery, Philadelphia and New York, Architect and Engineer.

Investigations and Contracts.

Reading is one of a number of American cities that have deferred the construction of a sewerage system until after attaining a comparatively large population. The last two national censuses showed 43,278 inhabitants in 1880 and 58,661 in 1890. Water-works were constructed by a private company in 1819-21 and bought by the city in 1865. In 1888 there were a few short storm sewers in use, but no provision had been made for a system of either storm or sanitary sewers. In June of that year the city council authorized the committee on sewers to employ Mr. Carrol Ph. Bassett, M. Am. Soc. C. E., "to prepare plans and general specifications of a comprehensive system of sewers and appurtenances." Mr. Bassett submitted plans and estimates in December, 1888. He recommended the adoption of the separate system, stating that some form of purification would be required eventually, but not at the start, and favored chemical precipitation, followed by mechanical filtration, or rapid straining, when it became necessary to treat the sewage. Little, if anything, was done to carry these plans into effect, and as time went on it became evident that the sewage would require treatment as soon as a collecting system was provided.

In the latter part of 1893 the city council directed Mr. S. S. Hoff, City Engineer, to prepare a general statement of the conditions to be fulfilled, and to advertise for plans, specifications and proposals for the construction of disposal works. In January, 1894, four bids were received, two being for chemical precipitation plants, one for chemical precipitation combined with rapid filtration, and the successful one being a combination of coke screening, aeration and rapid double filtration, as outlined above. Each bidder submitted plans and specifications for any system of disposal that suited his fancy, under the general conditions that figures were to be given on two 5,000,000-gallon pumping engines; land and a station suitable for a 15,000,000-gallon pumping plant; a 5,000,000-gallon disposal plant, with land enough for the treatment of 10,000,000 gallons of sewage, and also that the work should be satisfactory to the city officials and the State Board of Health. One bidder omitted the price for land, as noted below. The totals of the four bids were as follows: Bonnot Co., Canton, O., chemical precipitation, $123,000; Pennsylvania Sanitary Sewerage Co., Philadelphia, double filtration and aeration, $150,850; Wm. P. Dallett, of Philadelphia, and J. J. Powers, of New York, chemical precipitation (not including land), $168,950; Arthur J. L. Loretz, Brooklyn, chemical precipitation and rapid filtration, $322,750. The contract for the pumping station and machinery complete was awarded in March, 1894, to the Pennsylvania Sanitary Sewerage Co. In 1895 the same company was awarded the contract for an additional pump and boiler, the force main and the filter beds. The final cost to the city of the pumping station, force main, filter beds, with all necessary land and right of way, aggregated $198,725, not including engineering and inspection on the part of the city. This was divided as follows: Site for pumping station, $15,000; pumping station complete, $75,000; right of way for force main and land at filter beds, $8,725; filter beds complete, $100,000. In the spring of 1894 Mr. Hoff was succeeded as city engineer by Mr. E. Chamberlain, Mr. Hoff returning to office in April, 1897.

The contractors control certain patents on methods of pumping and filtering water and other liquids. The same general methods, in an earlier stage of development, were introduced in connection with the disposal plant of Atlantic City, N. J., in 1885, but the filter beds there were not enlarged to keep pace with the increase in the amount of sewage and have since been abandoned. The Atlantic City plant was described in Engineering News of Feb. 9, 1893. The contractors desire it to be stated that there is no similarity between the Atlantic City and the Reading filter beds, except the use of an elevated filter bed. Only one bed, the upper, was employed at Atlantic City. The plant there was a makeshift from the start. The force main has recently been extended and now discharges crude sewage into a large salt water channel.

The proposal of the contractor contained no definite indication of the results to be attained by the disposal works, further than that the service would be performed "in an economical and scientific manner" and "without any noxious or offensive odors." The drawings and specifications for the pumping station and filter beds were prepared by Mr. John Jerome Deery, architect, of New York and Philadelphia, and the disposal works were constructed under his supervision.

Pumping Station and Receiving or Screening Wells.

The pumping station is located in the city limits, within 150 ft. of the Schuylkill Canal and within 250 ft. of the Schuylkill River, the floor of the building being only 8 ins. above the canal level, and some parts of the work are below the bed of the river. Numerous springs were encountered during construction and one flood in the river. To guard against future floods the earth from the excavation was placed in an embankment around the building, held in place by retaining walls.

The building is fireproof, thoroughly drained, and has floors composed of concrete bases and granolithic cement surface. The interior is finished with red brick, laid in red mortar and the exterior is faced with light buff brick and trimmed

with molded brick and terra cotta of the same color.

A plan and section of the pumping station is shown by Fig. 1, and a view by Fig. 2. The sewage enters the station through a 54-in. brick sewer and passes to either one or both of the receiving and screening wells shown in the plan. Each of these wells is 20 ft. in diameter and contains broken coke, which is placed on a suspended screening floor constructed of wrought iron slats, with wire grating over the lower slats composed of No. 12 wire in ¼-in. mesh. The upper wrought iron grating or screening floor is placed over the coke bed, and is in five movable sections, while the lower screens or grates are set in a permanent position. The coke bed is 12 ins. deep. When the screens in one of the chambers become clogged the contents of the cages are shovelled into tilting buckets and lifted by a crane, the coke being dumped from the buckets into a brick steam-heated oven, designed to dry the coke and extract the grease therefrom, after which the coke is burned under the boilers. The screening wells are lined above the screens with white enameled brick and tiles, and below it with vitrified brick. They are provided with skylights and the spaces above and below the screens are supplied with abundant air from the ducts, and are ventilated through passages surrounding the smoke flue of the chimney, the latter being about 80 ft. high. The grease or coke oven is also provided with ventilating pipes discharging under the grates of the boilers.

At the pumping station the writer was informed on Aug. 9, 1897, that about 8,000 lbs. of coke per week are required to charge the screens, the coke in one set of screens being re-charged each week.

Mr. Deery states that after the plant was built the city adopted a plumbing ordinance requiring that grease traps be placed under all sinks. Consequently no grease of any amount has been collected in the oven.

The submerged river crossing was lowered in one section from trestles in the river, the length of pipe having been floated to line beneath the platform and lifted to positions parallel to the profile of the bed of the stream, the lead joints made, and then the whole lowered by means of screw rods at each joint. The city owns eight acres of land at the filter beds, the site being

Fig. 2.—View of Sewage Pumping Station at Reading, Pa.

bounded by the Schuylkill River, Angelica Creek, the Pennsylvania and the Philadelphia & Reading railroads. The latter road has a station adjoining the property.

Filter Beds and Their Operation.

A general view of the beds is shown by Fig. 3, and a view of the lower beds by Fig. 4. Figs. 5, 6 and 7 are plans and sections of the beds.

The upper bed is divided into ten compartments, each 25 × 50 ft., for convenience in cleaning. This bed rests on a grating of ⅞-in. wrought-iron pipe, the whole being supported by steel girders and columns. Upon the grating is placed about 6 ins. of slag, graded in size from 2 ins. at the bottom to ¾ ins. at the top. The filtering material is placed on the slag, and consists of fine bar sand. This sand, Mr. Deery states, was originally 2 ft. in depth, and it was intended by him that it should be maintained at that thickness. On Aug. 9, 1897, the writer visited the plant and was informed that the sand on the upper bed had gradually been reduced in cleaning to a depth of 14 ins., and was being maintained at that depth, the filters working "too slow" with a greater depth of material. Since the thickness of the upper bed was decreased breaks have sometimes occurred. One such break was visible when the writer visited the plant on Aug. 9, the sewage pouring down in a stream.

Regarding the decrease in the thickness of the beds we have received from Mr. S. S. Hoff, City Engineer of Reading, the following statement, dated Dec. 31, 1897:

> The reason we reduced the thickness of the upper beds was, as stated, to accelerate the flow through those beds, we depending upon the lower beds to make up any deficiency in purification which might thereby occur; the results have, in my judgment, fully warranted us in making this experiment. Since taking the slag covering off the lower beds we have experienced no clogging therein and have been obliged to clean the same but once during the past three months. Breaks in the upper bed rarely occur now and are repaired at once.

On this same subject Mr. Deery submitted the following under date of Jan. 3, 1898:

> The upper filter bed was originally 2 ft. in depth, and was so maintained by the Board of Public Works of the City of Reading until April, 1897, when the employees acting under their orders cut the depth of bed down to 6 and 7 ins. The reason assigned was that the city was not obliged to purify to such a high percentage, but should only obtain a result equal to that of the Schuylkill River in its normal condition, which they claim as much lower than the standard of purity produced by the plant as provided under my designs.
>
> The attendant measured the depth of the beds in my presence within the past month, and found that they were cut down so that there was but 6 or 7 ins. of sand over the broken stone and that this sand was not new material, but was the old sludge brought back from the dump and placed on the beds without any previous washing, burning, or other means of cleaning, so that it was placed there with the organic matter, fine silt, and other foreign substances which adhere to the particles of sand and form component parts of the mass. This practice has been in vogue since last spring. The result of such conduct is a detriment to the working of the plant, and, therefore, a great disadvantage to the working of the plant to obtain a high standard of purification, as also to cause the lower filter bed to receive a greater amount of organic matter than was intended, with the result that this lower bed clogs occasionally, and must be raked more frequently than before the change was made.

The surface of the upper beds was originally covered with wooden slats about 1½ ins. wide, and ½-in. thick, placed about ½-in apart, and nailed to cleats. Mr. Deery states that the slats are designed to keep the fine sand from being blown away when any of the compartments are not in operation, and also to prevent wave formation when the bed is covered with sewage. They can be removed for scraping the sand beneath and for their own cleaning. Half of the slats, or those beneath every second distributing main, were not in place on Aug. 9, 1897, only every other one of these mains now being used. Mr. Hoff states that a complete covering of slats is unnecessary and that they have dispensed with as many sections as possible in order to economize labor.

The usual head of sewage on the upper bed was designed to be 1 ft. Until the thickness of the filtering material was reduced this head could not be increased materially without causing the sewage to overflow.

The lower bed originally consisted of 3 ft. of

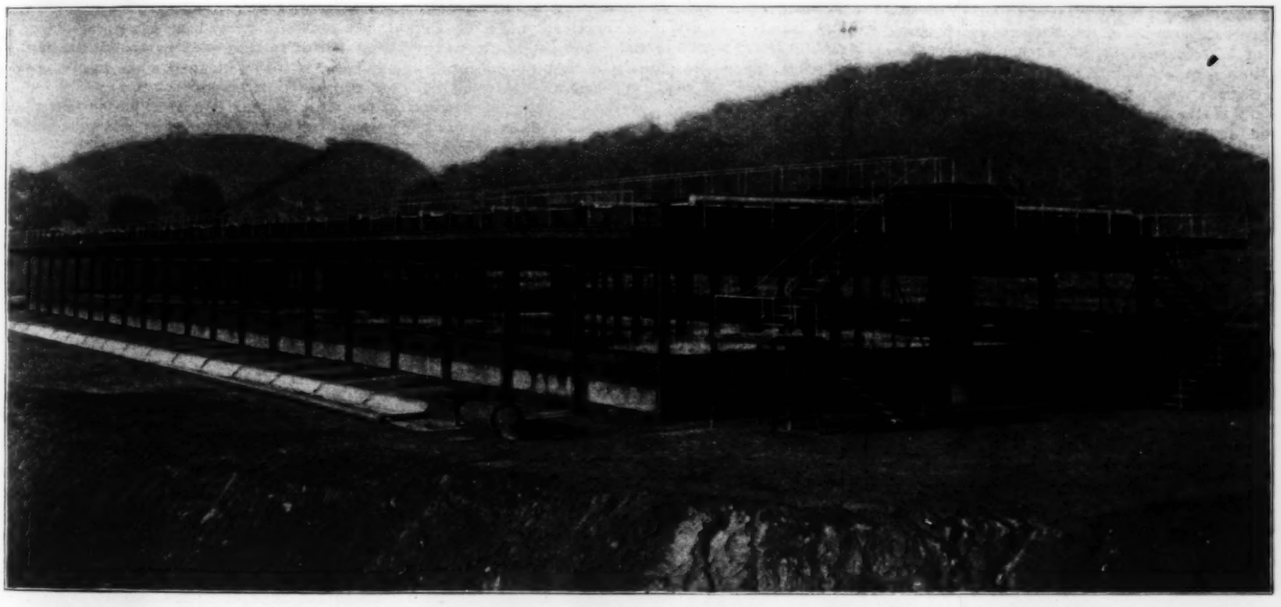


FIG. 3.—GENERAL VIEW OF SEWAGE FILTER BEDS AT READING, PA.

Two 5,000,000-gallon Snow compound condensing pumps have been provided, the suction and lift being about 18 ft. each. There are three boilers of about 60 HP. each. Coal is brought into the building by means of an elevated track, as shown by Fig. 1.

Force Main, River and Canal Crossings.

The filter beds are 6,600 ft. below the pumping station, on the other side of the river. The force main from the station to the filter beds is of cast-iron, 36 ins. in diameter beneath the canal and to the banks of the river for about 250 ft., then 30 ins. for about 450 ft. diagonally beneath the Schuylkill River, and thence 20 ins. to the beds. Provision has been made for a second 20-in. main.

coarse sand, with slag both above and below. The upper layer of slag was crushed and screened and was 2 ins. thick. It was provided to prevent the falling sewage from disturbing the surface of the bed. The sand in this bed is being reduced to 2 ft. in thickness and the upper layer of slag entirely removed. We are informed that a deposit formed between the slag covering and the sand, clogging the lower bed so completely as to make it overflow. Temporary relief was

The arrangement of the beds and the method of applying the sewage is designed to effect aeration. First the sewage falls in sheets upon the slats. After passing through the upper bed the sewage drops 10 ft. to the lower bed. The plant is intended to give the air continuous access to both beds from above and below. It appears to us that this will not be possible when the beds are covered with sewage and sludge, or the underdrain channels of the lower bed become filled with

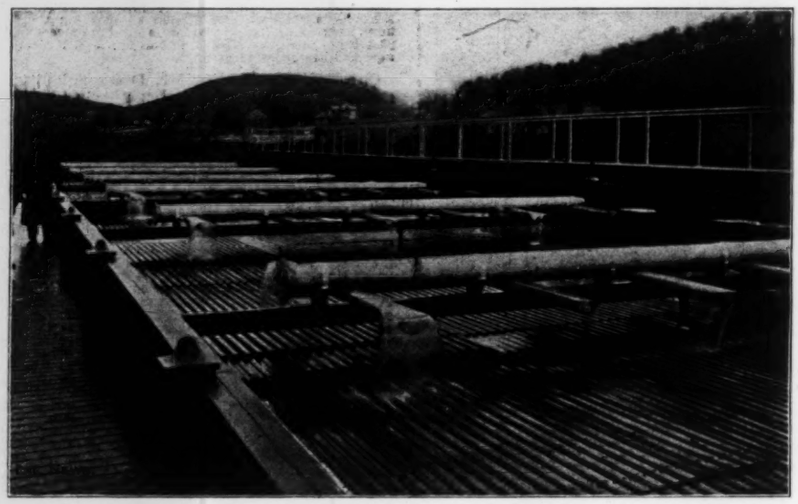


FIG. 4.—VIEW OF UPPER SEWAGE FILTER BED AT READING, PA.

obtained by removing the caps of the ventilating pipes, mentioned below. The lower bed was never cleaned, the deposit being inaccessible without removing the slag. It is interesting to note that the Lawrence experiments of the Massachusetts State Board of Health showed plainly some years ago that with a coarse material on top of a finer one a sludge deposit would be formed between the two. Mr. Deery states that this deposit would not have occurred at Reading had the slag been raked over, as intended, and had not the upper bed been so reduced in thickness as to result in poor work by it and the breaking through of the sewage at times.

The lower bed originally rested on the natural earth, brought to the proper level. The bases of the columns were 4 ft. below the established grade and from 5 to 12 ft. below the natural surface of the ground. Mr. Deery states that the upper layers of soil were of a good average character, but that at greater depths the soil becomes softer, while there are indications of a cavernous condition in the limestone formation below. In December, 1895, a few of the columns supporting a compartment of the upper bed sank, two of the beams broke, and a compartment of the upper bed came down. We think this may have been due to the constant saturation of the ground by the effluent. Concrete was placed beneath the lower bed in 1896.

Transverse channels are provided at intervals of 12½ ft. in the concrete floor for supplying air and for collecting and removing the effluent. These channels are 7½ ins. wide at the bottom, 18 ins. wide at the top and 8 ins. deep. They are continued to the effluent channel shown in Fig. 1. The underdrain channels are covered with iron grates and at their upper ends stand-pipes extend to the surface, for ventilation.

The effluent channel is of concrete, 4 ft. wide at the bottom, 6 ft. 2 ins. wide at the top, and 12 to 18 ins. deep. It extends 650 ft. to a 3×3-ft. riveted steel flume, 80 ft. long across Angelica Creek, from the end of which about 1,000 ft. of 24-in. sewer pipe extends to the Schuylkill River.

The 20-in. cast-iron force main passes along the center line of the upper filter bed, as shown in the illustrations. The laterals are 8-in. galvanized iron pipe and have distributing arms of 3×6-in. galvanized iron half cylinders on each side about 4 ft. c. to c. and 3 ft. in length, designed to discharge the sewage on the upper beds in thin sheets.

effluent, or if the beds are so saturated with sewage as to practically fill all the interstices of the sand, leaving no space for the admission of air from below.

The number of sewer connections made up to Aug. 9, 1897, was but 443, notwithstanding the fact that the whole plant had been in operation nearly a year, and the city had a population of nearly 60,000 in 1890. Many of the connections serve large buildings. The average daily amount of sewage pumped was given as about 1,250,000 gallons. Mr. Hoff states that on Dec. 31, 1897, the number of sewer connections was 528 and that the average daily pumpage was about 1,750,000 gallons; also that much ground water is taken into the sewers through house connections.

As the contract called for a purification plant capable of treating 5,000,000 gallons of sewage and the average pumpage when the plant was completed was only one-fourth of that amount, it is evident that the plant could not be properly tested before being accepted by the city.

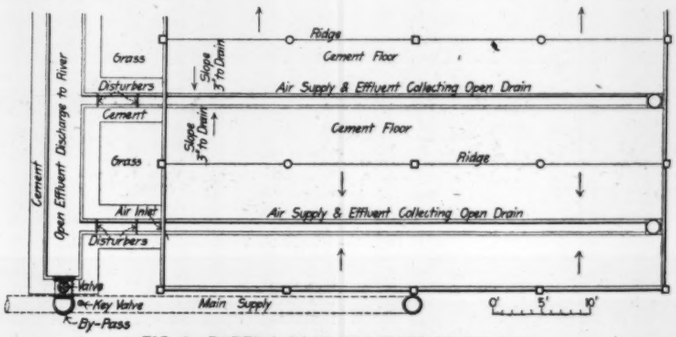


FIG. 5.—PARTIAL PLAN OF LOWER FILTER BED.

Official Test of the Filter Beds.

A 72-hour test was made and in lieu of sewage, water from fire hydrants was turned into the streets, dams being built across the streets, and "water carrying heavy street deposits, sand and manure, such as accumulates upon macadamized streets, and at the rate of 6,000,000 gallons" a day, says Mr. Hoff, was sent to the filter beds. Mr. Deery states further that garbage, manufacturing wastes, including oil wastes from gas works, were also turned into the sewer, and that there seems to have been a conspiracy to clog the beds. Mr. Deery adds that the beds "did their work admirably, sending off an effluent that was clear and colorless, while black sludge was deposited on the surface of the upper bed."

Although the plant was practically completed early in December, 1895, it was not put in operation until nearly a year later. On May 14, 1897, the use of the filter beds was temporarily discontinued, and the Board of Public Works reported to the city council, among other things, as follows:

The plant has evidently been badly constructed, ... to filter properly, has not been provided with sufficient filtering space for 5,000,000 gallons of sewage daily as promised. It has been proven that the plant cannot be run either by the board or Harry Deery, the superintendent recommended by the Pennsylvania Sanitary Sewage Co., without frequently using the by-pass.

Regarding the above, Mr. J. J. Deery states that Mr. Harry Deery was sent by the contractors to put the plant to rights, but that the local officials in charge at that time failed to co-operate with him and even put obstacles in his way, so that his efforts were futile and he resigned. A few weeks after the action reported in the quotation it seems that the personnel of the board changed, for Mr. Hoff reports a revolution at the filter beds, as follows:

On June 7, 1897, I, in conjunction with Mr. J. L. Boyer a member of the Board of Public Works, took full charge of the filter beds and have run the same uninterruptedly ever since without turning the sewage into the by-pass, excepting one day, and then to clean and spade the lower beds. This stoppage was not absolutely necessary, but the river at this time being in a freshet stage we took advantage of that fact and used the by-pass to save time and reduce the discomfort to the workmen, they being thus enabled to work free from water.

The attendant at the beds stated to the writer, on Aug. 9, 1897, that at times of heavy rains the sewage was turned into the river through the by-pass, evidently on account of the increased volume of sewage and the dirt washed into the sewers through perforated manhole covers. This practice, as stated by Mr. Hoff just above, has been discontinued. The attendant also said that since the thickness of the filtering material was reduced, no trouble has been experienced with clogging. Prior to that each compartment of the upper bed had to be cleaned after receiving sewage for from 6 to 24 hours, against two to four days at the date named. Mr. Hoff states that the compartments are now cleaned at intervals of from 24 to 40 hours.

Mr. Deery states that he believes the frequency of cleaning, in the past, as asserted by the attendant, who is an ordinary laborer, is greatly overstated, and that whether overstated or not, the thinning of the beds, and their renewal with the foul scrapings from the beds was responsible for the previous clogging and increases the necessary frequency of cleaning. He states that the compartments were operated from three to four days without cleaning when at their worst and that when in proper condition "the beds ran from 4 to 6 days without requiring cleaning and renewal of the surface."

Mr. Deery believes the plant was grossly mismanaged prior to the time it was shut down in May. There are indications that inharmonious relations between different branches of the city government, or political differences of some sort, have affected the operations of the plant, and especially the local reports concerning it.

In cleaning the upper bed shovels are used for removing the thin upper layer of clogged ma-

The sludge in the distributing arms is removed into buckets and the wooden slats are replaced. The fouled sand is placed in a pile near by.

The attendant states that no trouble was experienced from freezing last winter, provided the compartments were cleaned immediately after shutting off the sewage. Mr. Deery goes much further than this and states that at all seasons of the year the sewage is shut off at 6 p. m. from all compartments to be cleaned the next day and the compartments allowed to drain all night. In the morning these compartments are scraped and new material added. This practice, he says, has been followed "even while the thermometer has been at the freezing point or in the vicinity of zero." The beds, he states, are not thrown out of use by any freezing of their upper surface over night, the sewage quickly removing the frost. The deposit on the top of the bed is curled up, he adds, even in freezing weather, so that its removal is easy.

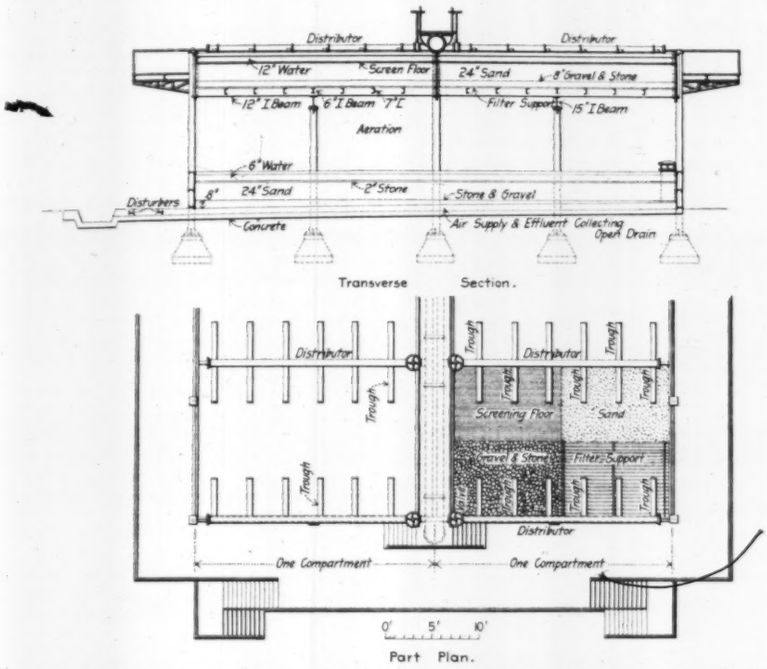


FIG. 6.—PARTIAL PLAN OF AND CROSS-SECTION OF SEWAGE FILTER BEDS AT READING, PA.

Regarding the amount of labor necessary to operate the filter beds, Mr. Hoff thinks that when the work at the beds is fully systematized six men will be sufficient for their operation.

When the writer visited the filter beds on Aug. 9, 1897, a very clear effluent was being produced and no offensive odor was detected. At a house near by it was stated that in muggy weather a decided odor was noticed, but that may have been while the plant was being operated intermittently. Mr. Deery claims that the odors, if any, have arisen from the pile of scrapings from the bed, which are near the house, and that the plant is without offensive odors.

Chemical and Bacterial Analyses.

The contractors for the plant have furnished us with two sets of chemical and bacterial analyses of the sewage at different stages of its progress through the works and with one chemical analysis of the effluent alone. Both sets of chemical and bacterial examinations were made by Drs. W. M. L. Coplin and H. F. Harris, Professors of Bacteriology and Pathology, respectively, in the Jefferson Medical College of Philadelphia. Dr. Coplin is Chief Bacteriologist to the State Board of Health of Pennsylvania, and made the bacterial examinations, the chemical analyses being made by Dr. Harris.

The samples for the two sets of analyses made by Drs. Coplin and Harris, were taken before the plant was tested by the city. The first set was collected when the beds had been in operation ten days, and the second set ten days later. The amount of sewage under treatment at the time is stated by Mr. Deery as about 2,000,000 gallons, five compartments being in use, each receiving about 400,000 gallons per day. This is a larger amount than was reported as being treated about a year later. The report of the analysts states that they forwarded "sterile containers" to Reading on Oct. 8 and that at noon of the next day they reached the laboratories, "sealed, the seal bearing the inscription, 'E. Chamberlain, City Engineer, per Charles H. Gerhard,' and all had been collected the morning of their delivery." The analyses were begun immediately after the receipt of the samples.

It will be noticed that in the first series of analyses the figures for chlorides vary materially, those for the crude sewage being 40% higher than the next three samples; also that in the second set of analyses the chlorides are the same for each sample. Chlorine is not affected by filtration, so if the samples were the same sewage at different stages of the process no variation in the chlorine would be expected. It is difficult to so time the taking of samples as to secure identical ones, so some variation is always allowable, but the 40% difference between the crude and screened sewage in the first series shows that the sewage was much stronger when the crude sample was taken than when the screened one was secured. As it is, no value attaches to the analysis of this sample of crude sewage, as compared with the other ones in the set, so the percentages of original bacteria and albuminoid ammonia removed would be misleading, except as showing the relative amount of each removal at each stage after the sewage passed the coke screens. On this point both sets of analyses indicate that the aeration of the sewage between the beds, and the filtration by the lower bed itself, effected but little purification, the bacteria being only slightly reduced and the albuminoid ammonia being affected the same way by the aeration and actually increased by the second filtration. In the second set of analyses 67% of the bacteria and 92% of the albuminoid ammonia are shown as removed by the coke screens, leaving comparatively little to the credit of the balance of the plant, although on the final round up of the bacteria only 0.004% of the original number were corraled. As to the insignificant part played by the aeration between the beds and the second filtration, as shown by these analyses, Mr. Deery states that in building another plant he would so modify the design as to divide the work more evenly between the two beds, using a coarser sand in the upper bed and thus lessening the labor of caring for it. He also wishes it stated that organic matter might have dropped from the walk above into the conduit at the time the sample from the lower bed was taken, thus accounting for the increase in albuminoid ammonia and bacteria, after the second filtration, shown by the first set of analyses; or that the increase may have been due to an unclean conduit, since crude sewage passed through the conduit for many months while the filter beds were being constructed. We think that either of these causes would have given rise to a more marked deterioration of the effluent.

In addition to the above comments regarding the analyses and their interpretation, Mr. Deery especially desires attention to be called to the fact that while by using percentages the effect of aeration between the two beds appears to be slight, yet that the number of bacteria after the filtration through the upper filter beds was 516.6 per cu. cm., and after aeration below upper filter bed, fell off to 126 bacteria per cu. cm., and that reduction taken place (was caused?—Ed.) by aeration before a second filtration. In the second test after filtration through the upper filter beds, there were 232.6 bacteria per cu. cm., and after aeration, without additional filtration, there were 81.2 bacteria to the cu. cm.

Taking into account the large numbers of bacteria present in the crude sewage and the reduction effected by other parts of the plant, we do not think that the actual numbers given by Mr. Deery are of any more significance than the percentages given by us above.

We have written to both Dr. Coplin and Dr. Harris, calling attention to the differences between the chlorine in the first set of analyses, asking if they could give us the nitrites and nitrates separately, and asking if they could explain why so much of the purification shown by the analyses should have been effected by the coke screens, and in general requesting their ideas as to what there is about this plant that would enable it to work successfully at its enormously high contract capacity, especially as the analyses show practically no purification after the sewage leaves the upper bed. Dr. Coplin has written as follows regarding the bacterial results:

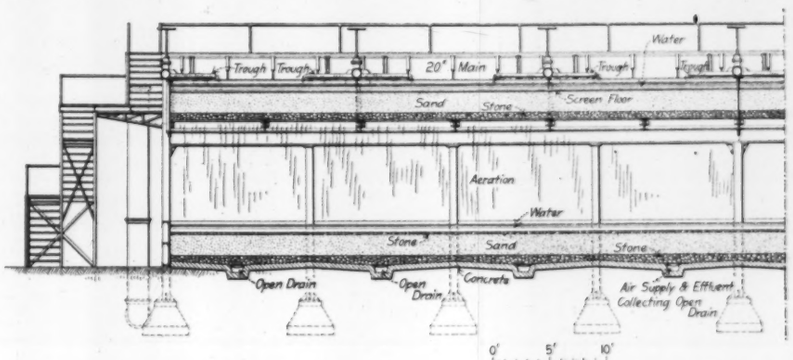


FIG. 7.—PART LONGITUDINAL SECTION OF SEWAGE FILTER BEDS AT READING, PA.

One of the factors which so much surprised me and has evidently surprised all those who have become cognizant of the investigation, is the remarkable reduction which takes place during the filtration through coke. This is accounted for largely by the fact that coke removes an enormous amount of solid material with which the sewage at Reading impressed me as containing an unusual quan-

Analyses of Sewage and Effluent from Disposal Works at Reading, Pa.*
(Parts per 100,000.)

	Chlorides.	Total hardness.	Oxygen consumed.†	Ammonia—Albuminoid.	Ammonia—Free.	Nitrites and nitrates.	Bacteria—Per cu. cm.	Bacteria—Per cent. removd.	P.c. albuminoid am'onia removd.
Samples collected Oct. 9, 1896.									
Crude sewage	9.0	15.54	3.95	0.140	0.340	0.429	27,232.8	.....	..
After coke screening	6.4	15.54	2.19	.090	.270	.650	19,152.4	.....	..
" passing upper bed	6.4	16.10	1.13	.020	.022	.673	516.6	.....	..
" aeration between beds	6.4	16.65	0.94	.015	.019	.787	126.0	.....	..
" passing lower bed	7.0	16.65	0.81	.025	.010	.984	22.0	.....	..
Effluent just before entrg conduit[1]	6.3	16.65	1.06	.032	.050	.756	182.0	.....	..
Water supply of Reading	0.4	8.88	0.75	.012	.005	.003	106.0	.....	..
Samples collected Oct. 19, 1896.									
Crude sewage	6.5	16.10	16.0	.730	.590	.420	49,867.3	.....	..
After coke screening	6.5	16.65	4.0	.060	.370	.305	16,542.7	66.83	92
" passing upper bed	6.5	16.65	2.0	.025	.055	.910	232.6	99.54	97
" aeration between beds	6.5	17.76	2.0	.040	.065	.951	81.2	99.84	95
" passing lower bed	6.5	17.76	1.8	.055	.010	.972	0.2	99.996	92

*All the samples showed an acid reaction and no trace of phosphates. †In the moist oxygen process for determining oxygen. [1]The analysts were informed that the conduit from which this sample was taken had been used for the transmission of crude sewage and had not been thoroughly cleaned before the sample was taken.

tity. I visited the works at Reading and found that the sewage was heavily laden with solid excreta, paper, leaves of trees and other vegetable matter, when entering the coke screens; it left the coke screens almost as clear as ordinary river water. This extraction of such a large quantity of solid matter accounts for the extraordinary reduction in the albuminoid ammonia and the bacteria. Great variations in the results occur during the examination of the samples collected at different times, the variation being dependent upon the amount of water which may be brought down with the sewage; after a rain the amount of solid material may be proportionately small, while after a dry spell, when the city is economizing in the use of water, the sewage may be so thick, with suspended solid matter, as to flow into the coke screens in a sluggish current.

In my opinion the bacterial efficiency of the plant is largely dependent upon the packing of the coke screens, and the thin filmy layer of organic material which forms on the top of the upper filter.

Both Professor Harris and myself entered into this investigation with a distinct belief that the filter could not by any possibility do what its originators claimed for it. The whole investigation was a surprise to me, and the results were so remarkable that we requested an opportunity to go over the matter in the second investigation to assure ourselves that the figures obtained in the first experiments might not have arisen by some error in technique, which we could not locate.

Regarding the failure to report the nitrites and nitrates separately, as is universally practiced where the results of water or sewage purification are being studied, Dr. Harris states:

That on account of the large quantity of organic matter present in the specimens, which I examined, I did not at the time and still do not think that a separate analysis of the nitrites and nitrates would be of any value, and hence the two were estimated together.

The other analysis mentioned was of effluent collected from five different underdrains on Feb. 13, 1897, when the beds were partially covered with ice and snow. The beds are variously reported as receiving from 1,000,000 to 1,200,000 gallons of sewage at this time, applied to but half the area, or 6,250 sq. ft. of each bed. The sample was collected by Dr. Chas. W. Page, Superintendent of the Danvers Lunatic Hospital, at Danvers, Mass. He submitted the sample to Mrs. Ellen H. Richards, of the Massachusetts Institute of Technology, Boston, for analysis. Her report to Dr. Page showed the following results, in parts per 100,000; Albuminoid ammonia, 0.0142; free ammonia, 0.0480; nitrites, 0.0030; nitrates, 0.24; chlorine, 5.76. Mrs. Richards informs us that the origin of this sample was unknown to her until she was informed by us, nor did she know that copies of it were in circulation; she simply made the analysis for Dr. Page.

One other set of bacterial analyses has come to our attention. These were made in May, 1897, by Mr. Fred Hollis, at that time assistant to Mr. Allen Hazen, Assoc. M. Am. Soc. C. E. They were made in connection with studies for the improvement of the water supply of Reading, the Pennsylvania Sanitation Co. having made a proposition to install a water filtration plant for the city. Before giving the figures it should be said that the analyses were made just before the plant was shut down in May. Mr. Hoff thinks the analyses are of little value, for he says that during May, 1897, the plant did not average one day per week in operation." Mr. Deery states that the beds were at that time reduced down to 7 ins. depth of sand, and that sludge from the dump pile was used, instead of fresh sand. The analyses are as follows:

	Bacteria per. cu. cm.	Per cent. removed.
Crude sewage at pumping station	302,400	..
Sewage on reaching upper bed	184,800	39
Effluent from first bed before aeration.	86,000	71
Effluent from main underdrain, after aeration and second filtration	58,500	80
Effluent as discharged into river	51,200	83

COMPETITIVE DESIGNS FOR THE CONNECTICUT AVENUE VIADUCT, WASHINGTON, D. C,

(With two-page plate.)

In the District of Columbia appropriation act approved March 3, 1897, the Commissioners of the District were ordered to obtain by competition designs for a bridge over Rock Creek on the line of Connecticut Ave., extended, and the sum of $2,000 was appropriated for this purposes. Upon consideration the Commissioners concluded that on account of the small amount appropriated it was best to restrict the competition to that number of competitors for which the fund would provide at least enough to pay the actual expense involved in getting up the designs. The engineers selected to submit designs were Messrs. W. H. Breithaupt and L. L. Buck, of New York, and Geo. S. Morison, of Chicago, all Members of the American Society of Civil Engineers. Mr. Breithaupt and Mr. Buck each submitted two designs and Mr. Morison submitted one design.

The prizes offered by the Commissioners were $600 for the best design, $500 for the next, and $400 for the third in merit. No competitor, however, was to receive more than one prize, since it was the cardinal idea of the competition that each competitor should receive some compensation for his work.

Perspective views of the four principal designs are published in our two-page plate and the salient features of each are described in the following paragraphs. To give a clear understanding of these designs a brief statement of the conditions governing the work is first necessary, however. This information has been furnished us by the courtesy of Capt. W. M. Black, Engineer Commissioner, District of Columbia.

Connecticut Ave. extends from near the Executive Mansion to the limits of the District, a distance of about 5 miles, and is 130 ft. wide between building lines. Bordering the portion of the avenue within the city are some of the finest residences in Washington, while between the c... its and Rock Creek, where the bridge will ... located, the improvements are all of the best ...burban type. Beyond Rock Creek to the Distr... line the development is all in the line of the san... high class of suburban residences. The site of t... viaduct being very conspicuous topographica... its proportions, type and style, it was rightly ... by the Commissioners, should comport with th... fact and with the dignity of the thoroughfare o... which it is a part.

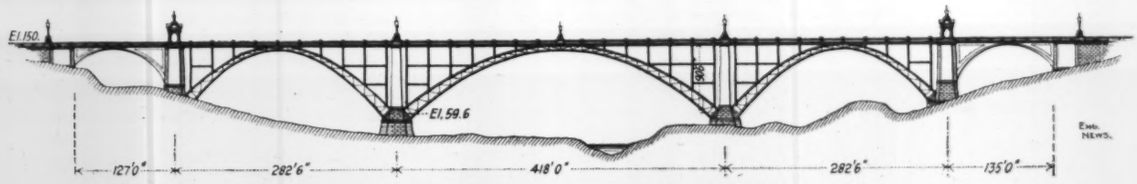
Structurally, the governing feature in the ...cation of the abutments and piers are Belmont ...ve., Water Side Drive, Rock Creek and a propose... new drive, all crossing the line of the viaduct. ... The grade of the bridge roadway was required ... be taken at 150 ft. elevation; the width of the roa...way at 50 ft., and the width of the sidewalks, on... on each side, at 10 ft. each. Provision had to be ...ade for two lines of conduit electric railways a...ss the viaduct, and also for water mains, gas ...ains and electric conduits. All metal work was re...ired to correspond to Cooper's specifications for ...eel highway bridges, edition of 1896, and all ma...nry to the Pennsylvania R. R. Co.'s current sta...dard specifications.

Passing now to the designs submitted by the three competitors, these will be described in alphabetical order. For the information from which these descriptions have been prepared we are indebted in each case to the engineer submitting the design.

Designs by Wm. H. Breithaupt.

Two designs were submitted by Mr. Breithaupt, one for the structure shown on our two-page plate, and the other for a viaduct with three steel-arch spans, flanked by a Melan arch at each end. This second design is shown in elevation in the accompanying engraving.

Design I. This design provides for a steel center arch of 544 ft. 8 ins. span, with two 225 ft. span Melan concrete intermediate arches and two end arches of 130 ft. and 115 ft. span, respectively, terminating in masonry abutment approaches. The arches are separated by masonry piers, with stone facing and concrete backing. The center steel arch is of the two-hinged type and is 95½ ft. deep at the ends and 9 ft. 9 ins. deep at the crown. It is made up of four arch ribs, thoroughly braced together by the floor system and lateral bracing in the plane of the bottom chords, and in the case of some of the longer web members by intermediate bracing. Each rib is divided into 19 panels, each 28 ft. 8 ins. long. All connections are riveted.



DESIGN FOR CONNECTICUT AVE. VIADUCT, WASHINGTON, D. C.
By Wm. H. Breithaupt, M. Am. Soc. C. E., New York, N. Y.

The floor system of the steel span consists of plate-girder floor-beams, riveted to the vertical web members at each panel point below the top arch chord. On these floor beams rest plate-girder stringers, two between each pair of arches, whose top flanges are about on the level of the top chords of the arch ribs. Resting on these stringers and the arch chords are 7-in. I-beams which carry a buckle-plate floor, covered with concrete and an asphalt pavement. The sidewalks come entirely outside the arch ribs and are supported by a longitudinal girder carried by lattice brackets at each panel point. The sidewalks proper consist of 7-in. I-beams and buckle-plates, leveled up with concrete and having a cement surface. The railing consists of posts at each panel point with an ornamental railing between.

The 225-ft. Melan arches are of rather novel construction. The metal work consists, first, of a series of arch ribs with horizontal top chords and curved bottom chords braced together by a vertical post and diagonal tie web system resembling the web system of the steel center arch. Between these main ribs, which occupy the full spandrel height of

[illegible] are curved girders occupying the height [illegible] arch ring only, as in the ordinary familiar [illegible] construction. The concrete work consists of [illegible] arch ring, vertical curtain walls, parallel vertical [illegible] spandrel walls, and horizontal concrete struts. The [illegible] curtain walls and the spandrel walls inclose [illegible] each arch rib each, and the concrete struts inclose [illegible] horizontal bracing between the arch ribs. At [illegible] tops of the spandrel wall are sprung a series [illegible] of concrete arches which carry the bridge floor. The [illegible] interior spandrel construction of the arch is thus made cellular to reduce weight and quantities as much as possible.

The end arches of 130 ft. and 115 ft. span are of the ordinary Melan construction with a spandrel filling of earth. While the sidewalks of the steel center span are carried by brackets outside of the arch ribs, in the Melan arches the width of the masonry is made great enough to include the sidewalks. The various ornamental features of the bridge are sufficiently explained by the perspective view.

Design II. The appearance and general construction of this design is sufficiently shown by the side elevation, published herewith, and it will not be described further.

The estimated cost of Design I. is $450,512 for a length of 1,434 lineal ft. For the same design, with sandstone facing, the estimate of cost is $590,000. For Design II., a structure of 1,319 lineal ft., the estimated cost is $372,159.

Designs by L. L. Buck.

Two separate designs were submitted by Mr. Buck, one for a Melan arch bridge throughout and the other for a bridge having a Melan arch at each end, and three steel arches intervening. The roadway in each design is 50 ft. wide, and there is a 10-ft. sidewalk on each side.

Steel Arch.—This design consists of five arch spans and two abutment approaches grouped symmetrically on each side of a 400-ft. center span. The steel spans on each side of the center span are 280 ft. long, c. to c. of piers, and are separated from the center span by masonry piers 20 ft. thick. These piers project outside the plane of the outside arches and the spandrel walls of the Melan arches, and are repeated for architectural effect between the steel and Melan arches, between the Melan arches and the abutments, and at the ends of the abutments. The abutments proper of the Melan arches are 30 ft. thick, and the arches themselves have spans of 112 ft. The abutments are merely retaining walls filled with earth and are 155 ft. and 185 ft. long, respectively, excluding the false piers at the ends. The total length of the bridge from end to end is thus 1,804 ft.

The two Melan arches have a vertical rise of 21 ft., the 280-ft. steel spans a rise of 69 ft., and the 400-ft. steel span a rise of 69 ft. Each steel span consists of four trussed arch ribs, spaced 20 ft. apart horizontally, and thoroughly braced tagether. The depth of these arch ribs at the ends is 81 ft., and at the center, or crown, 12 ft. Transverse girders supported at the panel points of the arches carry the roadway and sidewalks. A bronze railing surmounts the bridge at the outside edge of the sidewalks, passing around the projecting piers, which are provided with seats to form resting places and points of observation.

Melan Arches.—This design consists of seven Melan concrete arches of which the center arch has a span of 190 ft., the two arches on each side of the center arch spans of 175 ft. each, the two succeeding arches spans of 160 ft. each, and the two end arches spans of 105 ft. each. These arches are all segmental and in all but the two end arches the rise is 50 ft. The rise of the end arches is 29 ft. In this design, as in the steel arch, the piers project outside the planes of the spandrel walls and are continued througout the abutment for architectural effect. The roadway, pavement, sidewalk and hand rail construction are the same as described for the steel arch.

Design by Geo. S. Morison.

General Design.—The viaduct designed by Mr. Morison consists of five full centered masonry arches of 150 ft. span, each separated by piers 26-ft. thick at the springing lines, and of four full centered arches of 82 ft. span each, two at each end, separated from each other by piers 20 ft. thick and from the larger arches by piers 37 ft. thick. At each end is an apparently solid pier 34½ ft. long in the direction of the bridge, making the total length of the structure between the abutments 1,341 ft. or 21 ft. more than a quarter of a mile. The abutments are carried out square to the extremities of the avenue, so that the avenue can be graded to its full width behind these walls. The object in this design has been to obtain the requisite beauty by the massiveness, simplicity and correct proportions of the construction.

The main structure is 52 ft. wide or 2 ft. more than the width of the roadway between curbs, and the sidewalks are carried on cast-iron brackets and project 10 ft. on each side, including the railway. The structure above the main arches is divided into panels of 17 ft. each; these panels consisting of full centered arches of 14 ft. span separated by walls 3 ft. thick. Over the middle of each main arch these spandrel arches are omitted, but the panels, which correspond to the distance between the sidewalk brackets, are maintained throughout and the design is made in multiples of 17 ft., securing uniform details of construction as far as possible. Above the smaller arches the floor is leveled up with concrete, on which will be a gravel filling supporting the asphalt pavement.

Piers.—The piers are assumed to include everything below the height at which the arches must be laid on centering. It should be noted here that the spring line is in the pier and not in the arch masonry. The piers under the large arches have a batter of 1 on 24 in both ends and sides, the batter terminating at the spring line of the arches, but the piers of the smaller arches have vertical faces. Below the spring lines the piers are first-class, quarry face ashlar masonry, with 4-in. draft lines on the corners. At the elevation of the spring lines there is a belt course, 2 ft. thick, projecting 6 ins., and having a bush-hammered face. Above this belt course the masonry of the piers will correspond to the arch and spandrel masonry. The backing masonry may be concrete or a good quality of rubble. The pier masonry is estimated to cost from $10 to $12 per cu. yd., according to the quality of the stone used: the price, $12 per cu. yd., being for a granite face and the price, $10, for a cheaper stone.

Arches.—The large arches have a radius of 75 ft. on the intrados and 85 ft. on the extrados, the arch ring being 5 ft. thick at the keystone and apparently 10 ft. thick at the spring lines. In the smaller arches the arch masonry is 3 ft. 3 ins. thick at the keystone and the apparent thickness at the spring line is 6 ft. 6 ins. The total amount of masonry in the nine arches is estimated to be 12,743 cu. yds., and its estmated cost is $25 per cu. yd. for granite and $18 per cu. yd. for a cheaper stone.

Spandrel Walls and Arches.—The spandrel walls are everywhere 3 ft. thick and 14 ft. apart, in the clear, connected by brick arches 18 ins. thick. Over the piers these walls are connected by two curtain walls and two diaphram walls, also 3 ft. thick. These walls and the spandrel arches may be entirely of good, hard burned brick, laid in Portland cement mortar, or the face work on each side of the bridge may be of quarry face stone corresponding in general appearance with the ashlar face work of the piers and abutments.

Sidewalks, Railings, Etc.—The cast-iron sidewalk brackets, spaced 17 ft. apart, carry longitudinal I-beams 24 ins. deep, on which are supported 8-in. I-beams, spaced 4 ft. 3 ins. apart. The flagging forming the walk is carried by these 8-in. beams. The railing consists of a cast-iron post over each bracket and riveted steel lattice girders between the posts. The estimated amount of metal in the sidewalks is 620,080 lbs. of steel and 425,880 lbs. of cast iron.

The total cost of this design has been estimated on three different basis: (1) granite face work with backing and interior work as described; (2) a cheaper stone for face work and the same backing; (3) an entirely concrete structure. The figures are as follows:

	Granite.	Cheaper stone.	Concrete.
Foundations	$17,000	$17,000	$17,000
Masonry	907,000	738,000	543,000
Sidewalks	46,000	46,000	34,000
Paving, etc.	20,000	20,000	20,000
Engineering, etc.	99,000	82,000	61,000
Total	$1,089,000	$903,000	$675,000

For the guidance of the Commissioners in examining the several designs, a table of comparative estimates was prepared on the basis of uniform unit prices and length of structures, and is given herewith:

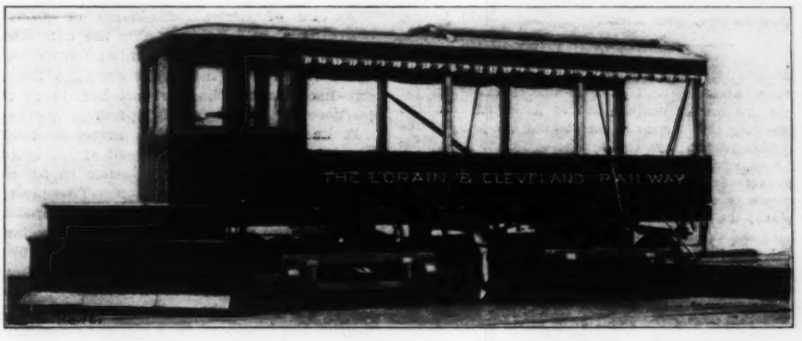
Table of Estimates as Modified for Comparative Purposes.

Design.	Description.	Material.—Granite.	Sandstone.	Concrete.
Morison's:				
No. 1	Masonry	$1,089,000	$903,000	$675,000
No. 10	Modification of same.	774,065	652,450	509,630
Buck's:				
No. 9	Melan	859,200	.....	(725,192)
No. 1	Steel	574,765	.....	.....
Breithaupt's:				
(Design I).	Melan & steel	.....	599,000	503,728
(Design II).	Steel	.....	437,748	.....

The decision of the Board of Award was in favor of Mr. Morison's design, with Mr. Buck's second and Mr. Breithaupt's third. We understand that the designs involving the Melan arches were preferred to the steel arch designs in the two latter cases.

A COMBINED CONSTRUCTION CAR AND SNOW PLOW.

We show herewith a construction car recently built by the J. G. Brill Co., of Philadelphia, for the Lorain & Cleveland Electric Ry., which has been so designed that it can be used as a snow plow as well, thus increasing the facilities of the road to cope with severe snow storms. The nose plow and the wings are readily mounted or detached from the car. In moderate storms the plow will clear the tracks more rapidly than a rotary plow and sufficiently clean for suburban and country road requirements. As seen by the drawing, the car has a vestibule on the front. The sides are 2 ft. high and are hinged in three sections. The rear drops as a single piece.



COMBINED CONSTRUCTION CAR AND SNOW PLOW.
Built by the J. G. Brill Co., Philadelphia, Pa.

The car has four General Electric 57 motors and electric brakes. It is mounted on two Brill "Perfect" trucks of standard gage, with 33-in. wheels and 5 ft. 9 ins. wheel-base. The car is 24 ft. long over all, and 6 ft. 1 in. wide. The sills are of yellow pine, 3¾ ins. × 8 ins., and are strengthened by steel plates ⅝-in. × 8-in. The advantage of such a construction for the sills seems questionable, and an all-steel construction would appear to us preferable.

THE SEMET-SOLVAY PROCESS OF COKE MAKING.*

The Semet-Solvay coke ovens are rectangular in shape, 30 ft. long, 5½ ft. deep and 16 ins. thick. They are completely surrounded, the top excepted, by a complicated system of flues, these being separated from the coking chamber by thin tile walls, about 3 ins. thick. Coal is emptied into the retorts through three hoppers at the flues surrounding the retorts. Usually 8 to 10 of these ovens are banked together, each with its system of flues being separated from the next by solid walls about 1 ft. thick, which serve to retain the heat. The heat attained in the flues is from 2,200° to 2,400° F. and in the coking chamber about 2,000° F. These retorts are closed at both ends, at one end by a slide door, at the other by one resembling a safe door. When coking is completed, the slide door is lifted and a piston of the shape of the coking chamber enters when the other door is thrown open and the coke pushed out. The doors are then closed and the retort is ready for another charge without any appreciable loss of heat. The first cost of a Semet-Solvay oven is about $1,550, the necessary ammonia condensers cost about $1,550 per oven, making a total cost of $3,100, as against $325 per oven for the old bee hive process. The bee hive ovens require extensive repairs after a few years use, while the Semet-Solvay ovens will run ten years without material repairs. The Semet-Solvay oven cokes about 4 tons of coal at a charge in 24 hours, while the bee hive oven cokes only 2 tons of coal in from 42 to 78 hours, the yearly output, therefore, of the former is about 4 times that of the latter. The coking chamber of the improved process having a larger surface exposed to the fire makes a much more uniform coke than the bee hive. Having the advantage also of 5½ ft. depth the pressure on the underlying coke is considerable and it is made harder and more dense than coke from the bee hive oven. Coking by this improved process takes place much like the freezing of ice, in that it cokes first at the side and later at the middle. As the gases are given off at the center only this portion of the coke is very porous. By actual tests it has been found that coke made by the Semet-Solvay methods possesses a decided advantage in the production of iron. By one test it was found that 546,150 lbs. of bee hive coke were consumed in producing 253 tons of iron, whereas Semet-Solvay coke from the same coal produced 200 tons of iron with the consumption of only 421,463 lbs. of coke. The useful by-products saved are ammonia, tar and an excellent fuel gas. The quantity of each produced per ton of coal is 9.88 lbs. ammonia sulphate, 43.5 lbs. of coal tar and from 9,000 to 10,000 cu. ft. of fuel gas. About 40% of this gas is required to furnish heat for the coking oven, leaving 60% as an article of commerce. The market value of by-products saved and available for sale is 48 cts. per ton of coke. From a recent experiment with a twelve-oven plant the net ultimate cost of coke per ton was 18¾ cts., while the net ultimate cost of bee hive coke is about 40 cts. It is estimated that with a larger plant the net ultimate cost by the improved process could be materially reduced. The importance of the Semet-Solvay process as tending to solve the vexing question of smoke nuisance in large cities should be seriously considered. In cities where coal could be obtained at a reasonable cost such a plant could be established to furnish fuel gas for domestic use and coke for the manufacturers and at the same time do away with smoke.

AN AMERICAN MAIZE EXPOSITION is proposed by the "American Agriculturist," as a means of extending the domestic and foreign consumption of American corn and thus benefiting the farmers by maintaining the price of this grain. This journal says that a raise of 10 cts. per bushel means $200,000,000 annual extra income to the producers, with an increase in price that the consumer will hardly feel. It proposes to exhibit the industries dependent upon the corn plant; the possible uses of the fodder, fiber, husks, cobs, etc., and the manifold uses of the grain as food, with all its by products. An appeal is to be made to Congress to stop the $200,000 annual distribution of seeds, which the people do not want, and to devote $100,000 of this sum annually in extending the use of corn, at home and abroad, under the auspices of the Department of Agriculture.

MULTIPLE RATE METERING FOR ELECTRIC LIGHTING SYSTEMS.

By Eustace Oxley.*

A new system of applying the double-rate method of charging for electric current has been successfully employed by a large electric lighting corporation† in this country for some five or six months past.

The system consists in the use of meters which register the actual consumption during the hours when the load on the station is heavy and which register a certain percentage below the actual consumption during the hours of light load, which is, of course, equivalent to giving the consumer a lower rate for current used at this time. The object, of course, is to induce the consumer to make a greater use of the current for heating, cooking, power, etc., during the hours when the load on the station is light. As everyone familiar with electric lighting knows, the great difficulty in making good profits in lighting from central stations is that the maximum load which the station must carry is so much above the average load and continues for so short a time that a considerable percentage of the station's machinery is never used except from half an hour to a couple of hours a day. Of course this maximum demand must be met; but central station managers are anxious to find some means of increasing their load during the daytime, by increasing their sales of current at this time without at the same time increasing their maximum loads.

At Brighton, England, it was found that an improvement of 3% in the load factor had the same effect in reducing the total cost of producing electricity as if the coal bill had been reduced 15%, the charge for coal in this case being $5 per ton.

The difficulties encountered in the use of a double-rate system of charging for current have been such, however, as to impede its adoption, although a large number of the leading central station managers regard it as the most complete and simple solution of the problem. The objections urged against it seem to have been due to faults in the means by which the method has been practiced, and not to any defects inherent in the principle.

Among the devices heretofore proposed, the best was probably that employing two separate meters, or meter dials, one to register all the current used during the hours when a low rate was charged, and the other to register that used, but at a higher rate. This required the two meters to act alternately. Their operative alternation was effected by a clock at each point of consumption. The expense of installing such an apparatus upon a system of even an average extent, would be large, and would materially increase the fixed charges. But a more serious objection was found in the great liability of clock gearing to stop, or become wholly unreliable. While this may be overcome to some extent, by using clock gearing of the best manufacture, the evil cannot be entirely eradicated, and the large increase in cost, due to the price of high grade clock movements, would not be compensated by the removal of the objections against the cheaper grades.

As one of the chief objects of a system of charging should be to enable the company to reduce the cost of generation, and lower the rates for current, a method that enlarges the running expenses, is, to that extent, hostile to the very purpose for which it is adopted.

It has been proposed to meter a double rate upon a single meter; the speed of the latter being varied by inserting a resistance in an auxiliary circuit at the central station. The plan was to connect all the meter shunts with a separate wire, run from the station to the points of consumption, and to vary the voltage on this wire, by the insertion of resistance at the central station to regulate the speed of the meters, so that they should register a part only of the current actually used, during the hours when a low rate was given. One objection to this method is, that the interruption of the auxiliary circuit would cause every meter to stop. A more serious objection, however, is that the necessary drop of voltage upon the separate wire would be likely to seriously impair the accuracy of the results obtained.

A single meter, however, can be used in a manner that removes all objection, and gives accurate registration by the use of some form of controller, a resistance can be inserted in each meter circuit, at the hour when the low rate is to begin, and maintained therein until the end of the low rate period. This resistance is graduated to retard the speed of the meter to a degree representing the ratio the low rate bears to the full rate. When inserted the meter will register only a part of the current that is used. By the insertion, the provision of an auxiliary circuit and the inaccuracy produced by line resistance are avoided. This plan has the advantage of economy, by saving the expense of a second meter at each point of consumption. The plan of using two meters, registering alternately, has the merit of simplicity, and is preferred, by the average consumer, who can easily understand it and calculate the amount of his indebtedness.

The chief difficulty in the way of the double rate method, or as it is sometimes termed, the differential rate, based upon the time of demand, seems to have been the absence of suitable mechanical appliancs by which two meters could be duly controlled, one to record current at a low rate and the other at a full rate and in such a manner as to fully protect the company against fraud, secure accuracy, and avoid any material increase in the fixed charges, due to large outlay for apparatus. A description of the apparatus, and the method of controlling it, as now installed by the United States Electric Lighting Co., is as follows:

At each point of consumption is placed a small electro-magnetic controlling-switch, enclosed in an aluminum case, 4½ ins. in length, and 3½ ins in width and depth. The working parts consists of two independent electro-magnets, indicated by the numerals 16 and 17 in the diagram Fig. 1, and a pivoted arm, 18, carrying an armature and knife contacts, and arranged between the electro-magnets. Upon each side of the pivoted arm are two clips, 22 and 24, which clips are connected by wires 27 and 28, to the terminals of the windings of the electro-magnets 16 and 17, the connection for each clip being made with the magnet lying on the other side of the pivoted arm. The second terminals of the windings of the magnets are connected (in a three-wire system) to the positive service wire, 9, and the neutral house wire 7a. Two clips, 21 and 23, one on each side of the pivoted arm 18, form part of the armature circuits of the two meters 1 and 2. These meters are high efficiency Thomson recording watt-meters, and they are connected with the controller at each consumer's premises, by a wire lead from the shunt, or armature circuit, to the right hand terminal at the top of the controller case. In meters having shunt circuits, such, for example, as the Edison chemical meters, as well as other types, the manner of connecting the controller is very simple. In some forms of meters, however, as those provided with a series winding only, a modified construction of the controller is used, by

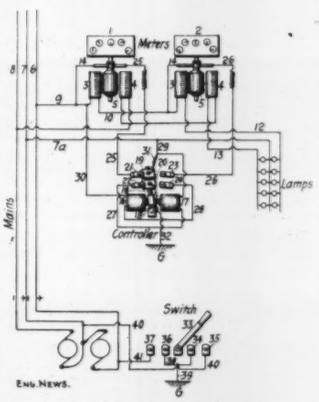


Diagram Illustrating Operation of Meters, Connections and Controller at Central Station in the Multiple-Rate System of Charging for Current as applied to a Three Wire System with Double Meters.

which each meter is wholly disconnected, when its period of registration is terminated. The pivoted arm 18, Fig. 1, carries two knife contacts, 19 and 20, one of which is connected to earth, and the other to the neutral house wire. The knife 20, having an earth connection, is struck into one or the other of the two clips, 22 and 24, which connect with the terminals of the two electro-magnets. It will be seen from the diagram in Fig. 1 that by throwing the pivoted arm, 18, to one side, the armature circuit of one meter is opened by the withdrawal of the upper

*Abstract of a paper read before the Engineering Association of the South, Jan. 13, by Dr. Wm. L. Dudley, of Vanderbilt University.

†The company referred to is the United States Electric Lighting Co., of Washington, D. C., and the system is the invention of Mr. Oxley, its general manager.

knife, 19, from one of the clips, 21 or 23, while the entrance of said knife in the clip on the other side of the pivoted arm completes the armature circuit of the other meter.

The whole system of meters is controlled from the central station, where a small double-throw switch is placed, Fig. 1. Two of its clips, 34 and 35, lie on each side of the switch arm 33, have an earth connection. Clip 37, in one side is connected to the positive, and the clip on the other side is connected to the neutral of the system. When the arm of the switch is thrown into the clips on one side, the circuit will be from the positive over the switch-arm 33 and clip 36 to earth, then at each consumer's station, by the lower knife 20 and the switch arm 18, through the clip 22, in which the knife 20 is lying, thence through the winding of the magnet 17, on the other side of the switch-arm 18, and then to the neutral house wire and main. The switch arms at all points on the system are by these means thrown simultaneously into the clips, opposite those in which the knives were resting. At the instant when the lower knife of the controller arm withdraws from the clip in which it rests, the circuit of the electro-magnet that produces the movement of the arm is opened at the clip. As the same knife strikes into the corresponding clip on the other side of the controller-arm 18, it completes at that point the circuit of the magnet which will be energized when the switch at the central station is thrown into the two clips opposite those in which the switch was previously closed. An indicator is arranged at the central station, to show at any moment at which rate current is being metered.

Several things are noticeable in the arrangement described: First, the automatic breaking of the circuit of the electro-magnet, by which the throw of the pivoted arm of the controller is produced, and the completion of the circuit of the other electro-magnet, at the opposite clip, by the same movement of the arm. Every controller upon the system thus cuts itself out automatically, by the simple movement of the pivoted arm 18. Second, the simplicity of construction, and arrangement of parts, by which liability to become disordered and tendency to depreciation are reduced to the minimum. Third, the extremely brief period that current remains on the control circuit, this interval being measured by the time required after one magnet is energized, to enable the knife, 20, to draw out of the clip which forms part of the circuit of that magnet. Finally, and this feature is the most important of all, the control apparatus throughout the entire system is controlled, and operated electrically from a single point (the central station), without the trouble and expense of providing a wire, or wires, for the control circuits. This is a feature of no small advantage in any case, but where the mains are not laid in subways, and where, as in the Edison system, the wires are piped, and buried beneath heavy block pavements or asphaltum, the labor and cost of laying a control circuit would be very great.

The controllers, which practically constitute the entire apparatus, are simple and inexpensive, and are connected and disconnected quickly and easily. Each controller takes from 1-40 to 1-20 of an ampere for its complete operation. The small current and the high resistance of the electro-magnets, which are wound with No. 40 wire, and have 2,000 ohms resistance, or more, render an ordinary resistance, due to a poor ground connection, of no consequence.

It is well understood that the standing charges may constitute at least 85% of the total annual expenses of a generating plant. The remaining 15%, therefore, represents the yearly running expenses, fuel being in most cases the largest single item. A central station, therefore, can double its output without adding to its expense account more than another 15%. Prof. Elihu Thomson, in speaking of the problems that confront central station managers, says that improving the load diagram is apparently of more real importance to them than methods that would double, or even treble the present coal efficiency; by which is meant the percentage of energy value of the fuel, converted into electric energy.

The duration of the hours of low rate will be fixed by the manager of the central station. The time at which this period begins will be regulated by the time at which the peak hours may be expected and this will be, in a measure, influenced by the season of the year.

The controlling switch at the central station is placed upon the switch-board at a convenient point. At the hour fixed for the change from one rate to the other, an employee throws the switch-blade on the switch-board into the clips which form part of the circuit of the electro-magnet that is to operate the pivoted arm of the controller. The switch-blade need not remain in the clips more than one or two seconds and in that time every pivoted arm of every controller on the system is withdrawn from the clips in which it rests and thrown into the clips on the other side of the arm. This action, where two meters are used, opens the armature or shunt circuit of the meter by which one rate is registered, and closes the corresponding circuit of the other meter. Thus the former ceases to act at the moment when the latter begins.

If a single meter only is installed at each point of consumption, the action of the controller is the same, but instead of the alternation last described, the throw of the pivoted arm of the controller simply inserts, or cuts out, a resistance in each meter circuit which varies the registering action to the required degree. The same result can be produced by causing the pivoted arm of each controller to shift the meter circuit from the two outside mains of a balanced system to one outside and the neutral. This varies the voltage in such manner as to produce a registering action of double the speed in one case, as compared with the other.

As it is possible that a temporary ground may accidentally occur on one of the mains, by which the controllers may be operated at the wrong time, a separate controller is mounted on the switch-board and connected in the same manner as the others that are placed at the several points of consumption. Upon the occurrence of a ground this controller will be the first to operate and will attract the attention of the employee at the switch-board, who will, in such an event, operate the main switch and thus restore all the controllers to their proper position. Means, however, have been provided by which this result can be accomplished automatically by a very simple apparatus.

The method described of metering a double rate as here described is covered by a series of letters-patent, issued during the last few months:**

DETERMINING THE MOISTURE IN STEAM PIPES.*

By D. S. Jacobus, M. Am. Soc. M. E.†

The paper describes a special method of obtaining a sample of steam, and states the best way of employing throttling calorimeters in determining the moisture contained in steam.

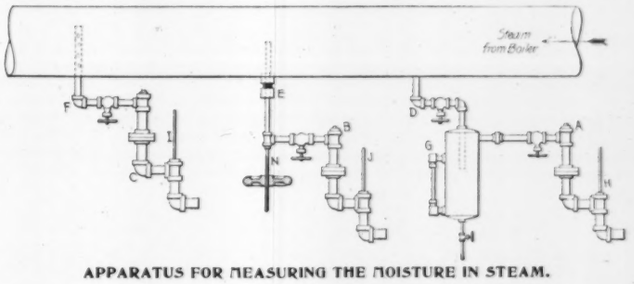
Results of earlier investigation proved that the ordinary form of perforated collecting nipple is not reliable for use in gleaning the average sample of steam from the entire mass flowing through a steam main. It was also shown that in a horizontal pipe of sufficient length, and for the velocities of steam which occur in ordinary practice, the water collected at the bottom, and ran along in a small stream, which could be wholly drained out in most cases by means of a small drip-pipe leading from the bottom of the pipe.

The experiments show that all that can be done with certainty in determining the quality of a large mass of steam flowing through a main, by gleaning out a small sample of steam and passing it into the calorimeter, is to ascertain whether the steam is practically dry, or whether there is a considerable amount of moisture present. It is impossible to ascertain with certainty the exact percentage of moisture, unless the entire mass of steam flowing through the main is dealt with. If the entire mass of steam is passed through a separator, and the steam leaving the separator is found to be dry, then we can determine the amount of moisture in the steam by weighing the water drawn from the separator. The entire mass of steam can also be throttled, and the temperature measured after throttling, which would be equivalent to passing the entire mass of steam through a throttling calorimeter, and from this temperature the moisture could be accurately determined, but ordinarily the steam cannot be wasted, and such a method cannot be used.

Another way of determining the moisture for the entire mass of steam is, to attach a drip-pipe to the bottom of a horizontal main, at such a distance from an elbow, or bend, that the water will have time to fall from the steam and collect, and run along the bottom of the pipe in a small stream, and to draw out the moisture through the drip-pipe instead of collecting it by means of a separator. If the steam beyond the drip-pipe is found to be dry, then the percentage of moisture may be found by weighing the amount of drip water. It is a method based upon this principle, which it is the special object of this paper to describe. We have obtained reliable data in employing it, and there are advantages possessed over other methods which will be pointed out.

Three Barrus throttling calorimeters were employed, connected as shown in Fig. 1. The calorimeter A was attached to the separator G which was in turn attached to the bottom of the pipe by means of the nipple D, the end of which was made flush with the inside of the pipe. The calorimeter A was run continuously and any water running along the bottom of the pipe flowed into the nipple D and was removed by the separator G. The calorimeter B was attached to a nipple with no side holes, which could be forced in and out of the stuffing box E by means of the screw N. A sample of steam could thus be obtained from any section of the pipe and led to the calorimeter B. The calorimeter C was attached to the perforated nipple F, which extended nearly to the top of the pipe.

If the calorimeter B indicates dry steam for all positions of the adjustable collecting nipple in the steam main, then the steam passing it is dry and any moisture in the steam has been drawn out by the drip-pipe and collected in the separator G. The calorimeter B will sometimes indicate dry steam for all positions, except when the adjustable nipple is lowered so as to drain out any moisture there may be directly at the bottom of the pipe. If this is the case, the moisture which enters it may be caused by the radiation of the length of the main steam pipe between D and E, or by the small amount of water which may not be removed by the nipple D.



APPARATUS FOR MEASURING THE MOISTURE IN STEAM.

If, when the nipple is at the lowest position, there is any superheating shown by the thermometer J, that is, if the thermometer registers a temperature of over 212° F., and at all positions of the adjustable nipple the thermometer is high enough in its readings to indicate dry steam, it is safe to assume that the moisture which enters the nipple when at the lowest position is from one of the above causes, and to consider that practically all the moisture in the steam has been drawn out through the nipple D.

The calorimeter C, connected to the perforated nipple F, serves to show that there is no moisture distributed through the steam, and in case of a sudden belch of moisture it would indicate it. The lowest hole in the perforated nipple F is made about ⅝-in. above the bottom of the pipe.

If the steam in the pipe is dry, or practically dry, there will be no water, or very little water, collected in the separator G, and the calorimeters B and C will indicate dry steam. If there is moisture drawn from G and the calorimeters B and C indicate dry steam, then the percentage of moisture may be obtained by weighing the water drawn from the separator G.

We cannot measure the amount of moisture closer than about 0.2% with throttling calorimeters, because we have to calibrate the throttling calorimeters to determine the normal reading, or the reading of the thermometers for dry steam, and we can vary the quality of what may be called dry quiescent steam to an extent that will cause a variation in the normal reading of 3° F., which is equivalent to about 0.2% of priming. This difficulty does not disappear if the theoretical formula is used, in which case the normal reading need not be determined by experiment.

**Nos. 588,170, Aug. 17, 1897; 591,194, Oct. 5, 1897; 591,195, Oct. 5, 1897; 593,852, Nov. 16, 1897.

*Abstract from a paper in "The Stevens Indicator," Oct., 1897.

†Professor of Engineering Physics in the Stevens Institute of Technology.

The separator G, combined with the calorimeter A, forms a Barrus universal calorimeter, and experiments have shown that with a properly constructed separator the steam passing into the calorimeter or "heat gage" portion of the calorimeter, as it is called by Mr. Barrus, will be practically dry when there is as high as 60 lbs. of moisture drawn from the separator per hour. This is for a throttling orifice ¼-in. in diameter, which is the size we have adopted in all our tests.

This gives a ready means of determining the normal reading of the thermometer used in the calorimeters B and C, which can be placed in the calorimeter A in turn and a record taken for, say, one hour before replacing them in B and C.

The calorimeters are run continuously, and are all of the same form and covered with felting or other material in the same way to diminish their radiation, so that by obtaining the normal reading in this way we correct for all radiation as well as any error in the thermometers.

The pipe leading from the separator G to the calorimeter A is of the same length as that leading to the calorimeters B and C. The normal readings obtained by placing the thermometers in A are therefore affected by radiation to the same extent as the readings of the thermometers in B and C, and as the difference of the readings is employed in the calculations, the radiation will not affect the result.

The method of calculating the percentage of priming in the steam passing through the calorimeters B and C is as follows:

If N is the normal reading, Deg. Fahr., obtained by placing the thermometer in A;

T, the reading when placed in either B or C;

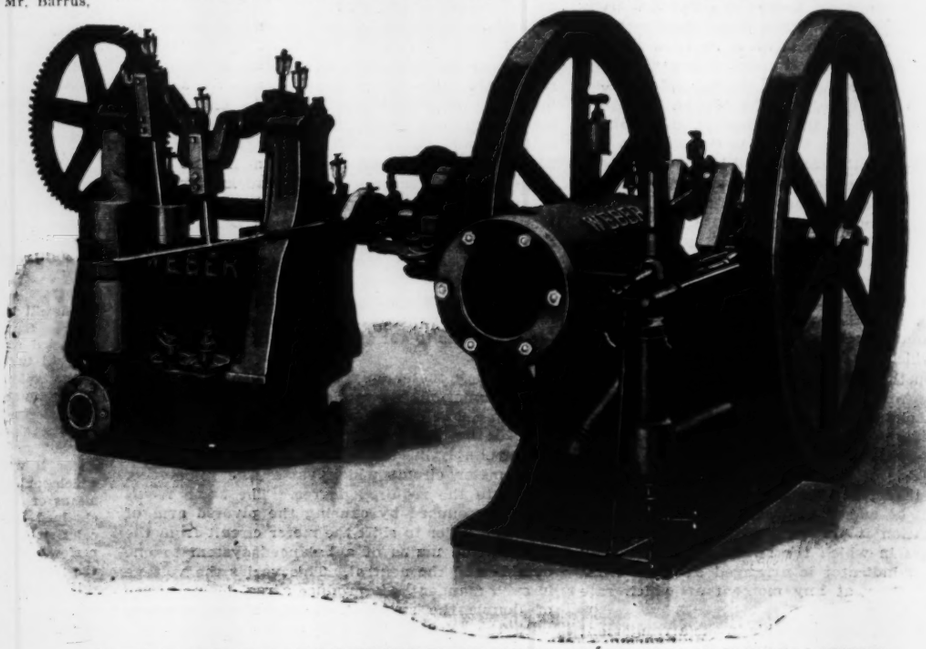
L, the latent heat at the pressure of the steam in the steam main in B. T. U. per pound;

Then the percentage of priming for the steam passing through the calorimeter is $\frac{48}{L}(N - T)$.

A GAS ENGINE PUMPING PLANT WITH DIRECT CONNECTION.

We illustrate herewith a gasoline pumping plant at the Fuller Mines in Yapavai Co., Arizona, which has recently been installed by the Weber Gas & Gasoline Engine Co., of Kansas City, Mo. As seen by the engraving the pump is of the triplex pattern, with its shaft in line with that of the engine, and connected to it by a clutch. The builders inform us that this plant is pumping 80 gallons of water a minute, which supplies a 10-stamp mill. The water is forced through a 3½-in. pipe line 3,126 ft. long, with a total rise of 156 ft. About 10 gallons of gasoline per day are consumed, which costs there 20 cts. per gallon.

The most valuable feature in connection with the plant is the fact that it runs all day without an attendant. In the morning the oil cups and the gasoline reservoir are filled and the machine is started, and runs without further attention till night. We are indebted to the Weber company for the cut used in our illustration.



DIRECT CONNECTED GASOLINE PUMPING PLANT FOR THE FULLER MINES, YAPAVAI CO., ARIZONA.
Built by the Weber Gas & Gasoline Engine Co., Kansas City, Mo.

QUESTIONS USED IN THE EXAMINATION OF CANDIDATES FOR THE NAVAL CIVIL ENGINEER CORPS

Many of our readers will remember that when a vacancy was to be filled last summer in the corps of civil engineers of the navy, the numerous candidates for the vacancy were given an examination by a board detailed for that purpose by the Secretary of the Navy. As it was desired to select the very best from the many young engineers who desired the position, the examination was made exceedingly thorough. Through the courtesy of Hon. John D. Long, Secretary of the Navy, we are enabled to publish the questions which were used in the examination, for the benefit of our readers. We think our readers will generally agree, after a perusal of the questions, that the two young engineers who attained a high rank in this examination, and who received appointments in the corps, fully demonstrated their abilities to fill the positions assigned them. We print the examination questions in full, as follows:

General.

(a) Give name in full? (b) Are you a citizen of the United States? (c) Where born? (d) Date of birth? (e) Present age in years and months? (f) Present address in Washington? (g) Usual address: town, county and State? (h) If a regular graduate of a technical school show diploma conferred or certificate of proficiency given. (i) State length of practical experience as a civil engineer and kind of work engaged in. (j) If not a regular graduate of a technical school, or if no certificate of proficiency has been given for partial or special course or courses, state in detail the actual instruction received, both in regard to length of course and kind of instruction given and where given.

English Grammar.

(1) Define grammar. (2) Into how many parts is English grammar divided? Name and define each. (3) Name the parts of speech. Define and give an example of each. (4) Define mood as used in grammar. Name and define the different moods and give an example of each. (5) Name, define and give an example of the different classes into which verbs are divided.

Composition.

The general character of the examination papers will be considered as an evidence of the candidate's knowledge of composition.

Arithmetic.

(1) If 12 men can do a piece of work in 12 hours, how many hours will it take 8 men to do the same work? (2) A piece of cloth, when measured with a yard measure, that is ⅔-in. short appears to be 10½ yds. long. What is the true length? (3) A merchant mixes 3 lbs. of coffee worth 27 cts. per lb., two lbs. worth 35 cts. per lb. and one lb. worth 41 cts. What is the mixture worth a lb. (4) At an average price of 55 cts. per bushel and a charge of 2½% commission, how many bushels of grain can be bought for $4,510. (5) Find the value of the following expression correct to seven places of decimals:

$$16 \times \left\{ \frac{1}{5} - \frac{1}{3} \times \frac{1}{(5)^3} + \frac{1}{5} \times \frac{1}{(5)^5} - \frac{1}{7} \times \frac{1}{(5)^7} + \&c. \right\} - \frac{4}{239}$$

Algebra.

(1) Factoring. Separate the following expression into its simplest factors: $(x^8 - y^8)$.

(2) Reduce the following complex fraction to a simple one:

$$\frac{a + b + \frac{b^2}{a}}{a + b + \frac{a^2}{b}}$$

(3) A man contracts for a certain number of cubic feet of filling at the rate of 2 cu. ft. for 3 cts., four times as much for 15 cts., for 12 cu. ft., five times as much at 24 cts. for 20 cu. ft., and received for the whole $1.32 per 100 cu. ft., gaining by the transaction $1.26. How much did he contract for altogether?

(4) Determine the value of x from following equation:

$$\sqrt{(x + 5)} = \frac{12}{\sqrt{(x + 12)}}$$

(5) Write an expression for the (nth) term of an increasing arithmetical progression of which the first term is (a) and the difference is (d).

(6) Write the (nth) term of an increasing geometrical progression of which the first term is (a) and the ratio is (r).

Analytical Geometry.

(1) The equation of a straight line being $5y + 3x + 4 = 0$, trace it with reference to rectanguar co-ordinate axes.

(2) Find the equation to the circle referred to any rectangular axes.

(3) What curve is represented by the equation $y^2 = 4px$. Trace this curve.

(4) What is an ellipse?

(5) Find the equation to the ellipse.

Differential Calculus.

(1) Differentiate $\frac{2x}{3a}$, $\frac{x}{a-2}$ and ax^2, (a) being constant in all cases.

(2) Given $\frac{x}{a} + \frac{y}{b} + \frac{z}{c} = 1$; express (dz) in terms of (dy) and (dz), (a), (b) and (c) being constants.

(3) Divide a number into two such parts that the square of one part multiplied by the cube of the other part shall give the greatest possible product. Find the product.

Integral Calculus.

(4) The general form for determining the areas of plane figures by integration is $\int y\,dx$, having given the equation of a parabola $y^2 = 4px$; determine the whole area of the parabola by integration between the limits of $x = 0$ and $x = x$.

(5) Determine by integration the volume of a sphere whose radius is (a).

The general formula for volumes of figures of revolution is:

$$\pi \int_{\alpha}^{\beta} y^2\,dx$$

The value of (y) in terms of (x) is obtained from the equation of the generating curve.

Elementary Physics.

(1) Describe an hydraulic press giving a theoretical explanation of its action, neglecting friction.

(2) Define specific heat, giving the standard unit. British or French.

(3) Explain the formation of the solar spectrum, briefly.

(4) Give Ohm's law, and name the units when the law is expressed in the form of a formula.

(5) What HP. is required to drive a current of 4.16 amperes through a resistance of 21.4 ohms. (The HP. referred to is electrical HP.)

Examination in Geology.

(1) Define geology.

(2) Name the four principal divisions of geological time.

(3) State the principal rock and ore formations characteristic of each of these geological divisions, and the appearance of the forests.

(4) What are the two general geological formations? Give examples of each.

(5) Into what two general sections are the rocks divided?

General Principles and Mechanics of Fluids.

(1) a. Explain briefly what is meant by Moment of Inertia and Radius of Gyration, and deduce by integral calculus the expression for the moment of inertia in general. First for an eccentric axis. Second for an axis passing through the center of figure.

b. Find the value of the moment of inertia of a rectangle about an axis in its plane passing through the center of figure and parallel to the shorter sides.

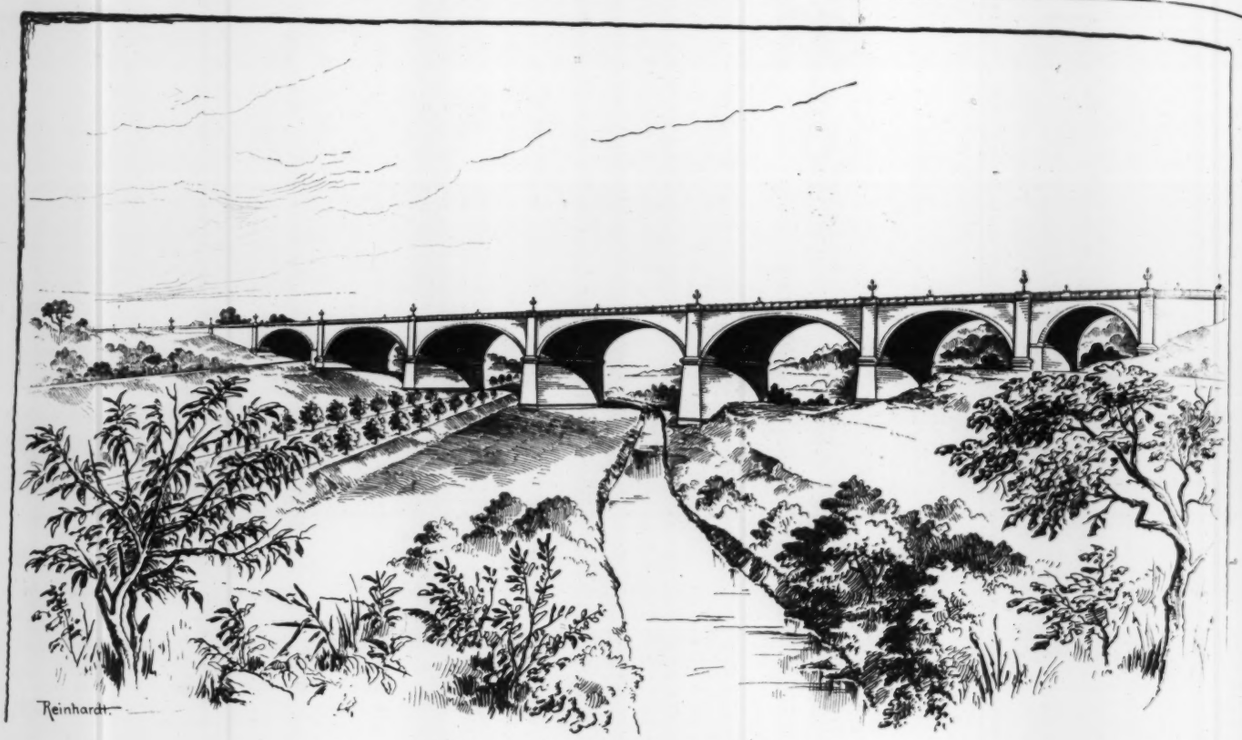
(2) a. Deduce an expression for the position of the center of pressure of any immersed vertical plane surface by means of the integral calculus.

b. To what is the pressure exerted by water in any direction upon a surface equal? Give the answer without any demonstration.

(3) Discuss the principle of the resolution of forces in one plane, briefly.

(4) Find the thickness of a pipe of circular cross section (any metal) to resist a given internal pressure not greater than 100 lbs. per sq. in.

The result to be expressed in terms of the radius of



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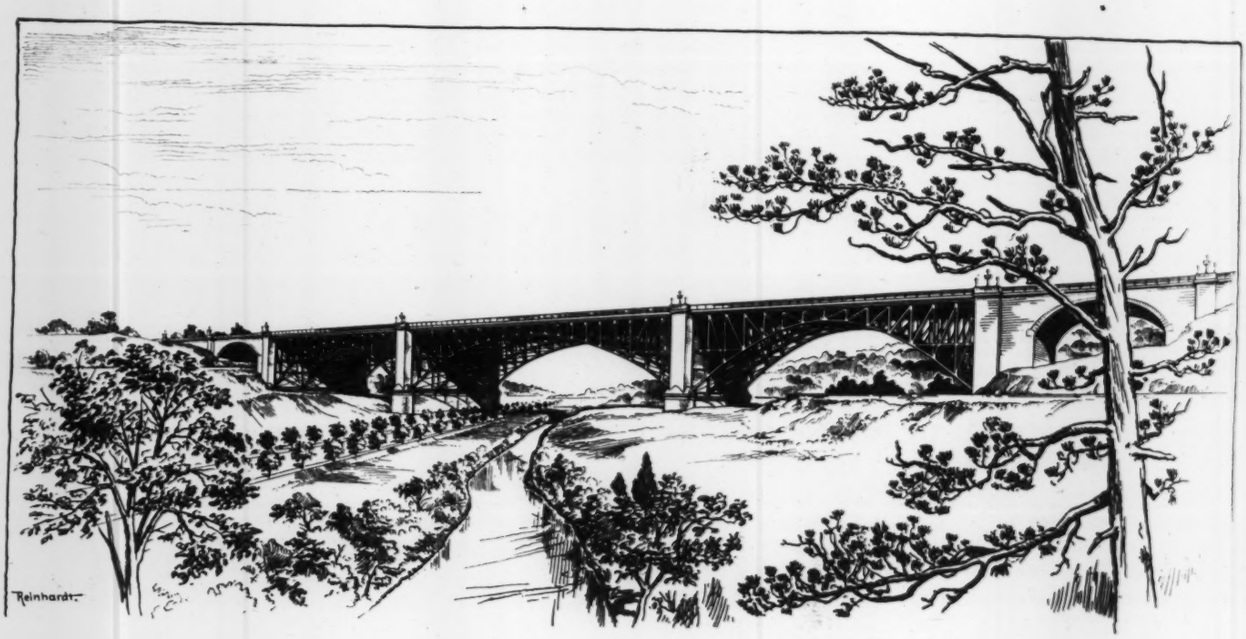

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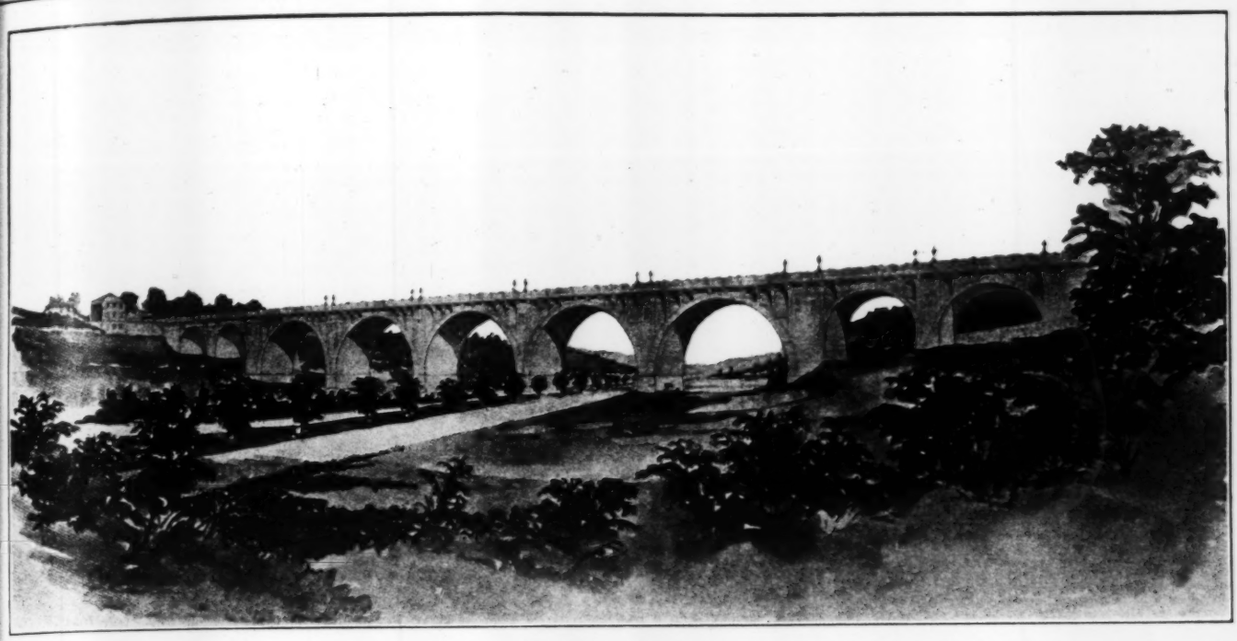
COMPETITIVE DESIGNS FOR CONNECTI AV

Capt. W. M. Black, Engineer iss



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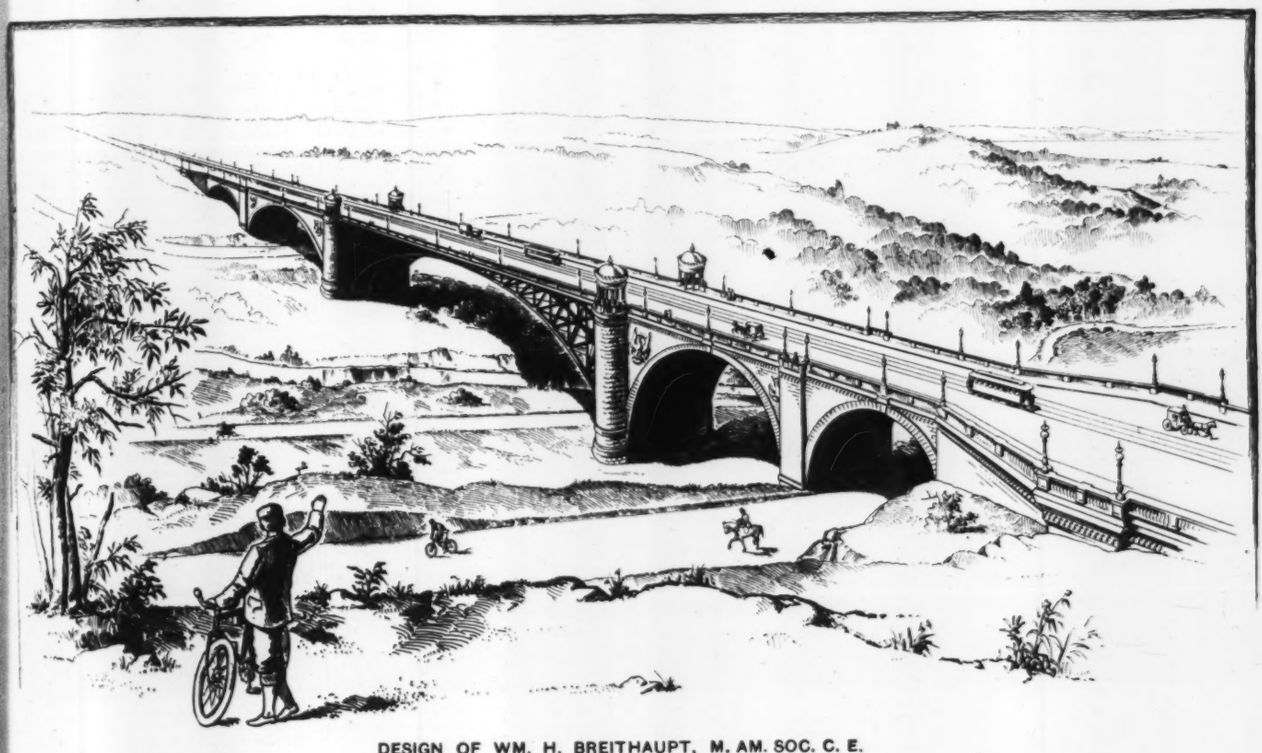

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interior circumference (R), the pressure per unit of area (P) and the resistance of the material for each unit of section (B).

(5) a. Give an expression for the hydraulic mean depth.

b. Give an expression for the hydraulic inclination.

c. How would you gage a stream for its discharge?

d. Give details of the process.

e. What data would you require to calculate the slope of a river, say for 10 miles of its length, and how would you proceed to obtain it?

f. A boat-shaped caisson is in place and the dry dock pumped out; describe by a sketch and in a few words what volume represents the amount of the displacement of the caisson.

Friction.

(1) a. What is it, and how measured?

b. How many kinds of sliding friction, and define them?

c. What is a coefficient of friction?

d. Upon what does the amount of friction depend?

e. State the fundamental laws of friction, and whether or not they apply to solids and liquids alike and the reason.

f. What is the angle of friction? Illustrate it in the case of one solid sliding upon another, and derive the expression from the coefficient in terms of this angle.

(2) Show how to find the amount, direction and point of application of a fluid pressure acting against the plane face of a wall. Fig. 1:

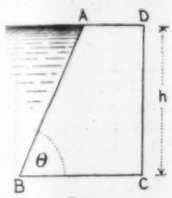

Fig. 1.

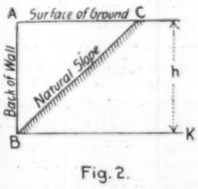

Fig. 2.

Let h = depth of fluid supported by wall.
ϕ = angle which face of wall makes with horizon.
w = weight of one cubic foot of fluid.
p = total pressure along one foot in length of wall face.

After the value of (p) is obtained for the above case give it for $\phi = 90°$.

(3) Show how to find the amount, direction and point of application of the thrust of earth against the vertical back of a wall. Fig. 2:

Case I. Where there is supposed to be no friction between the wedge and the plane which supports it..

T = horizontal earth-thrust against vertical back of wall per foot (lineal).
h = height of back wall.
w = weight of 1 cu. ft. of earth.
φ = angle natural slope makes with the horizon.

Give the expression for T.

Case II. Where friction is supposed to exist between the wedge and the plane which supports it. Find the horizontal thrust H.

H = horizontal thrust behind vertical back of wall, taking friction into account.
b = height of back wall, A. B.
φ = angle of repose of earth, C. B. K.
w = weight of 1 cu. ft. of earth.
α = angle of rupture.

Give the expression for H.

If this were a quay wall, what other force or forces would have to be taken into consideration?

(4) Show how to find graphically the amount and point of application of the horizontal thrusts of earth against the back of a wall supporting a surcharge, Fig. 3:

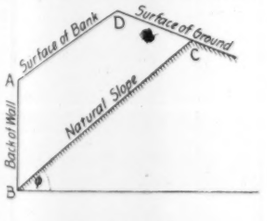

Fig. 3.

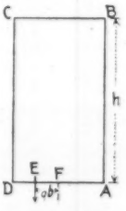

Fig. 4.

φ = angle of repose of earth. α = angle of rupture.

(5) Transform a rectangular profile of retaining wall (Fig. 4) into one of equal strength having a sloping face. Show why the portion cut off can be removed without affecting the stability of the wall. Let the resultant pressure cut the base A. D. in E.

b = breadth of wall A. D.
h = height of wall A. B.
qb = deviation of center of pressure from center of base, E. F.

Chimney. (Fig. 5.)

Give expressions for the maximum and minimum pressure upon foundation, per unit of area, produced by the wind.

P = maximum pressure on foundation per unit of area.
P' = minimum pressure on foundation per unit of area.
p = pressure of wind per unit of area.
w = weight of the structure above the section considered.
S = area of the horizontal section.
M = moment of the wind.
l = distance A. B.
L = moment of inertia of section considered.

Wind pressure upon the side B. E.

What is necessary in order that the chimney does not overturn from wind pressure?

Upon what does the intensity of draught required depend?

Crane. (Fig. 6.)

Show how to compute the strains on a crane by construction. Let A B C represent the crane, A B the suspension rod, A C the jib and B C the crane post fixed at C. Illustrate the computation by a sketch.

Prefix the proper signs for tension and compression.

Construction Material.

(1) Lime.—(a) State from what lime is manufactured and how. (b) State the ordinary tests for lime (means of determining quality). (c) State how it is prepared for mortar. Cement.—(d) Give the kinds used in this country. (e) Describe the manufacture and from what materials. (f) Give the tests employed and the manner of making them.

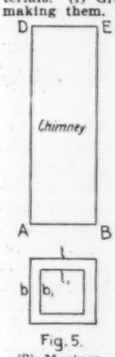

Fig. 5.

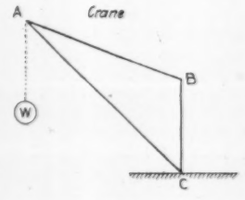

Fig. 6.

(2) Mortars.—(a) Lime—describe the preparation. (b) Cement—describe the preparation. Concrete—(c) Give the ingredients, the method of incorporation and the method of laying.

(3). Iron and steel.—State briefly the kinds of these materials, their characteristics, methods of manufacture and the methods of determining their quality.

(4) Timber.—Write specifications for yellow pine timber for first-class wharf work. Timber to be sawed by contractor who supplies it.

(5) Building stones of the United States.—(a) State the several classes or groups of stones used for building purposes, with the especial components of each group and their characteristics. (b) Give the tests and examinations employed to determine their quality. (c) State the order of the average durability of the several groups.

Sewers.

(1) Describe what would be the general procedure for installing a sewer system in a manufacturing establishment, composed of work-shops, offices and dwellings, for the removal of the water-closet and urinal wastes of 2,000 persons, maximum service required during eight hours a day. All surface and storm waters to be excluded. Main sewer to discharge into river. Water supply system already installed.

(2) Describe in general terms the form, size and kind of material to be used for the system.

(3) Describe in general terms the method of its construction.

Wharves.

Prepare sketch showing front and side elevations and write briefly the general specifications for the construction of a wharf on piles, of the form and dimensions shown in the accompanying sketch, Fig. 7.

Top of wharf to be 11 ft. above M. L. W.

Depth of water along front of wharf to be 25 ft. below mean low water. Character of bottom, stiff clay at a depth of 25 ft. below mean low water. Wharf to be used as a landing and temporary storage place for all kind of building materials delivered by vessels. Wharf to be capable of sustaining a load of 400 lbs. per sq. ft. of surface.

Water Distribution.

(a) What data enter into the calculations for the size of main necessary, and what elements appear in a formula for determining the diameter of the main and branches.

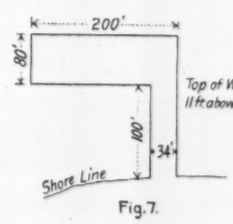

Fig. 7.

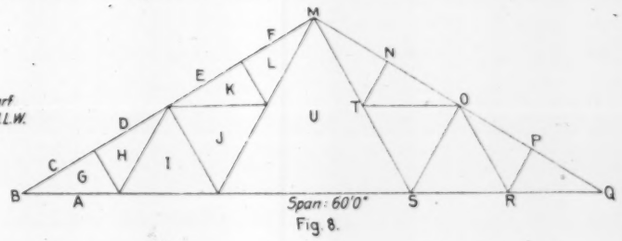

Fig. 8.

(b) What conditions determine the depth at which the main and branches should be laid and state the requirements for good laying and refilling of trenches.

(c) Describe the making of a lead joint in bell-mouthed pipe.

(d) When and how would you make tests of the work.

(e) Enumerate the important tools to be provided for the work.

Foundations.

Give the different classes of foundations. State how the bearing power of soils in ordinary foundations is improved. Mention the different kinds of piles, and the methods of sinking them. Give a formula for the bearing power of a pile sunk by impact. Describe briefly the methods of putting down the various types of foundations under water.

Dry Docks.

Make a rough sketch of a masonry dock of any length, 70 ft. Width of floor with the coping 5 ft. above high water and 35 ft. above the floor of the dock. Make cross section through body of dock. The dock to be founded in a compressible soil and the entrance to be located 100 ft. inland from the tidewater. State its general features, and the method of carrying out the work, the plant and appurtenances necessary for the operation of the dock. State what are the forces and conditions affecting its stability both from the natural situation and its use by a ship.

Yard Railways.

(a) State how to lay out a simple curve.

(b) Describe the construction after grading until the rails are laid.

(c) Make sketches of a frog in plan and cross section, one riveted and the other bolted. A single-throw steel switch. A single-throw split safety switch and a double turnout. Sketch one crossing, the tracks intersecting at an angle of about 45 degrees, the sketch to show two methods of support, and cross section of angle-bar joint.

(d) From what data would you calculate the elevation of the outer rail on a curve.

(e) Name the outfit of tools required for the work of construction of a yard railway.

Pavements.

Describe and discuss briefly the pavements usually laid down for wheeled traffic.

Quay Wall.

(1) Make sketch (showing construction) of a section of a quay wall. a. Wall to be of concrete with granite coping. b. Top of coping 10 ft. above mean low water. c. Depth of water in front of wall to be 28 ft. at mean low water. d. Foundation firm stiff clay at 26 ft. below mean low water. e. All submerged timber free from destruction by marine life. f. Concrete wall to start from plane of mean low water.

(2) What change, if any, would you make in the design of the above quay wall, if all exposed timber below water would probably be destroyed by marine life?

Workshop.

(1) a. Design a machine shop.

Dimensions: 200 × 65 ft., out to out, walls 30 ft. high. Materials: brick, steel, wood and slate. Foundations in a soil which will sustain 1,000 lbs. per sq. ft. at a depth of 1 ft. and 2,000 lbs. at a depth of 10 ft., soil wet at a depth of 5 ft.

No cranes to be provided for beyond support for a 10-ton traveling crane to traverse the length of the building and to have a transverse range of nearly half the width of the building. Weight on upper floor 250 lbs. per sq. ft. No wood allowed in construction of lower floor, which may have to sustain 400 lbs. per sq. ft. Roof trusses of steel. Construction to be measurably fireproof. No interior division into shops or rooms. No boiler room or chimney. State what portions of this construction you would make the subject of mathematical calculation. No calculations required. Plan, longitudinal and cross sections to be sketches.

(1) b. A flat length of steel of good commercial quality 10 ins. wide and ⅝-in. thick to be used in construction of this workshop; is found to have been furnished in two short lengths instead of one long length. The sum of the two short lengths is, however, several feet longer than necessary. There is no time to order a new length. The ends of the two short lengths are all identical. Describe in detail with sketches the method of riveting the two short lengths so that the loss of tensile strength shall be reduced to a reasonable minimum. You are supposed to have good mild steel rivets ¾-in. in diameter and of sufficient length and number. Describe briefly and carefully every practical detail of this work as well as the location and size of rivet holes, giving brief reasons for everything. Assume shearing strength of rivets to be 70% of the ultimate tensile strength of the flat lengths.

Chimneys.

(a) A brick chimney 80 ft. high of 9 sq. ft. internal area. Rock at depth of 15 ft. below grade, above that depth the soil affords little lateral stability. What foundation would you put in and how? What would be the features of the superstructure and the method of construction?

(b) In the same situation, erect a steel chimney of an equivalent interior section and describe the construction and erection. No calculations upon stability or capacity required.

Masonry.

Stone.—State the classes and kinds used in engineering and architectural constructions with their subdivisions. Describe them and give the proper methods of laying.

Brick.—Describe or illustrate the bonds and give proper method of laying.

Strains in Roof Truss.

Construct a diagram of the strains in the left hand half of the truss (Fig. 8) by the graphic method and tabulate the results.

Calculate the strain in one each of the following members in the right hand half of the truss, viz., rafter, strut and tie, by another method.

The only loads considered to be those of snow and the weight of the roof, a total of 40 lbs. per sq. ft. of superficial roof surface.

Pitch of roof 30°. Trusses spaced 10 ft. 8 ins. c. to c.

The drafting work will be traced as part of the examination in drawing. Span 60 ft.

Surveying.

(1) Land Survey.—a. Describe briefly the purpose of a land survey. b. Describe briefly how the field work is done.

(2) Topographical Survey.—a. Describe briefly the purposes of a topographical survey. b. Describe briefly how the field work is done.

(3) Hydrographic Survey. a. Describe briefly the purposes of an hydrographic survey. b. Describe briefly how the field work is done.

(4) Mapping.—Describe briefly how an hydrographic survey is mapped or plotted.

Instruments.

(1) Name the instruments most generally used for the different kinds of surveys mentioned above and for engineering field work.

(2) Name the most important adjustments for these instruments, in the order in which they should be made.

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ADVERTISING RATES: 20 cents per line. Want notices, special rates, see page 28. Rates for standing advertisements sent on request. Changes in standing advertisements must be received by Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

The comparative popular valuation of the services of the lawyer as compared with those of the civil engineer is well expressed in the case of the present controversy concerning the removal of the Commissioners in charge of the construction of the New East River bridge. Here is an engineering structure demanding the highest class of professional ability and experience, and, probably, the most important work of an engineering nature now under construction in this country. Many millions are to be expended upon it, and the final efficiency of the bridge, the economical expenditure of a vast amount of money, and the safety and convenience of the great numbers who will use the bridge for generations to come, depend solely upon the judgment, skill and experience of one man—the engineer in charge. Yet, in the wisdom of the commission, a salary of about $10,000 per year is considered ample for all the responsibility shouldered by this engineer; and the majority of the dear public, doubtless, consider this an extravagant sum to pay out for engineering services. It is, in fact, considerably above the average salary allotted for engineering services by corporations, either public or private.

On the other hand, the same commission pays out about $75,000 for two and one-half years' work of a legal counsellor; and instead of a protest against the charge it defends its action by saying that this sum is far less than would have been paid by private parties in equally important business. As far as we recall, the chief outcome to the city of these expensive legal services was the recommendation to pay a couple of hundred thousand dollars for the extinguishment of a franchise, which should never have been granted; and for this sum the city practically received no return. It is true that the lawyer may have saved the city from later litigation; the payment of further sums to other gentlemen of the legal profession, and of a possibly larger sum to the owners of the interfering franchise. But if the only excuse for this outlay for legal advice was a wise economy in the handling of public funds, then the engineer of the bridge was fully entitled to at least an equal financial recognition with the lawyer. What the public does not yet realize, is that a bad engineer is liable to cost it quite as much in wasted funds as a bad lawyer. The mistakes of the engineer, indeed, are likely to have much more serious results, because he alone shoulders the responsibility, and he is usually unquestioned as to plans and details until the mischief is done; while the blunders of the lawyer stand a good chance of being uncovered by opposing counsel or by the ruling of higher courts.

It is evident that the true relation of the ability, technical training and wide experience of the engineer to the actual expenditure of money and the general efficiency of a great public work, is not appreciated as it should be. In fact, in the case of this new East River bridge, some members of the new commission, representing a new party in power, seem to believe that tried technical fitness for the position held is of slight weight when compared with the political faith of the engineer in charge. The position thus taken by those responsible for the wise or unwise expenditure of public funds for a great public improvement is directly chargeable to their ignorance of the true value of the engineer in this connection. But the fact that such things can be is humiliating to the whole profession of engineers, and emphasizes the necessity for using every proper means to place the profession on a better footing. If money saved or wasted is to be made the standard of valuation of personal professional services, the engineer of great enterprises ranks with the ablest lawyer engaged on similar work.

We reviewed at length in our issue of Nov. 18 the projects for increased traffic facilities across the East River, but recent events make some further comment appropriate. The agitation concerning an "all-railroad" bridge has culminated in the presentation of bills at Albany looking to the construction of such a bridge, or at least of another bridge to be located between the existing bridge and the one which is now under construction. Just why an "all-railroad" bridge would be such a desirable acquisition to the consolidated city, we have never been able to understand. The fact is that the pedestrian and vehicle traffic across the present bridge is so trifling compared with the railway traffic that it is practically an "all railroad" bridge. So must any bridge be which crosses the river at an elevation of 140 ft. or so, and reaches nearly a mile in its total length. No matter where it be located, heavy trucks will use the ferries rather than climb over such a hill, and only pedestrians bent on exercise or loafing will walk across rather than ride.

As for locating a third bridge in the vicinity of the present and the new bridge, it appears to us that it would be sheer waste of public funds. Certainly nobody but the dear public would undertake such an enterprise. With the increase in the traffic facilities on the old bridge and the opening of the bridge now under construction, the sections of the city properly tributary to these structures will have all the facilities for crossing the river that it can make use of for years to come. Moreover, if the city is too poor to undertake an entreprise promising such sure return as the Rapid Transit railway, it surely cannot afford to spend money for East River bridges.

If, however, the influences are such that money is to be spent on more East River crossings anyway, a site should be chosen where facilities for crossing do not now exist. A bridge at Blackwell's Island, for example, could be built for a fraction of the cost and in a fraction of the time required for a suspension bridge farther down the river. At present the greatest need for traffic facilities across the East River is not for residents of Brooklyn but for dwellers in the Long Island suburban towns. If the Long Island R. R. Co. will invest its money in bridges or tunnels to effect this end, it should be given every facility; and if the city can gain added transit facilities by cooperating with that corporation in making a crossing either at Blackwell's Island or downtown below the present bridge, it might be of advantage to both the city and the company.

We publish in this issue an illustrated description of the sewage purification plant at Reading, Pa. Such a high rate and high degree of purification have been claimed for this plant that we have investigated it with unusual care. A member of the editorial staff has twice visited and examined it, and a full hearing has been given both to the engineer who designed the plant, and the city officials in charge of it at Reading. Our description aims to present both the claims of those who have designed and built the plant and the results of our own investigations.

In the system of purification employed at Reading, the sewage is first screened through coke, then filtered twice, the sewage being mechanically aerated in dropping from the first filter bed to the second, which is immediately below. Each filter bed is designed to work at a contract rate of over 17,500,000 gallons per acre per day, or more than 8,500,000 gallons for the two beds, without allowance for beds out of use for cleaning or other causes. We see nothing in the design of the plant to warrant the assumption that it could be worked successfully at such a rate.

The average daily pumpage at Reading at the close of 1897 was about 1,750,000 gallons, according to Mr. Hoff, the city engineer, or about one-third the contract capacity of the filter beds. Therefore, the beds can never have been worked for any considerable time, at anything like their contract capacity. The few analyses that have been made afford very meager data upon which to base an opinion as to the efficiency of the plant. The latest analyses, the contractors reject as being based on samples collected when the city had let the plant run down. Another analysis is of effluent, only, and is, therefore, useless, since the crude sewage may have been highly diluted. The contractors base their claims for the efficiency of the plant, as shown in operation, upon two sets of analyses made 10 and 20 days, respectively, after the beds were put in operation and while they were being run by the contractors. We have pointed out in the article that the first set of these analyses is of very doubtful value, except as showing the relative amounts of work performed by different parts of the plant. We are, therefore, left with but one set of analyses, made when the plant was new and in the hands of its friends, and when the quantity of sewage treated must have been very small. As to the general experience of the city of Reading in operating the plant, we have given a full account in our description, and need only remark here, that while the plant has apparently been mismanaged, there are indications that many of the difficulties experienced have been due to faults of design, and that these troubles would increase with an increase in the amount of sewage treated.

In conclusion we are compelled to say that in our opinion the claims made for the plant are not proven; that the contract rate of filtration is many times beyond the capacity of the plant to perform; that the expense involved in elevating the upper bed is not warranted by the results shown; and that the city of Reading could have built for less money filter beds that would have done far more work than can ever be expected from these.

We said in our issue of Jan. 6 that the state of New York ought to turn the Erie Canal over to the United States for improvement, if for no other reason, because public opinion in the state will not permit the expenditure of more money upon the canals, and without a radical enlargement and improvement, traffic on them will soon fall to a point where it will not be worth while to keep them up, if indeed that point has not already been reached. A canvass of members of the legislature has recently been made by the "Herald" with results which are summarized as follows:

Total members interrogated, 117.
Opposed to expending more money on canals, 47.
In favor of expending $7,000,000 additional if it is submitted to the voters, 33.
Non-committal, but disposed to say, "Hang the canals!" 37.
In favor of leasing or selling the canals to the Federal Government to get rid of them, 57.
Opposed to lease or sale, 22.
In favor of Federal control only if there is to be a ship canal, 38.

In the newspapers throughout the state, those in sections off the line of the canal are generally opposed to further expenditure on canal improvements. In the canal counties and in New York, a large sentiment has developed which favors dis-

posal of the canals to the Federal Government, and many oppose further expenditure on the canals under any circumstances. The few newspapers which urge that the state should retain and improve the canals at its own expense, resort to some curious arguments. One is that since up to the present time the total of receipts from the canals during the years when tolls were charged, exceeds all that has been spent on them to date, the state can afford to spend at least the balance of the profit which it made. In other words, what would be absurd financiering on the part of a business man is all right for a state government. Many a silver mine which paid enormous dividends thirty or forty years ago cannot be worked at a profit to-day; but its owners do not think it necessary to spend upon the mine all they took out of it before they close it down.

Some very sensible suggestions concerning the canal situation have been made by ex-State Engineer Martin Schenck, in a published interview. He says, among other things, that the reason why the actual cost of the work has risen so far above the original estimate is that it was attempted to do considerably more than was contemplated in the original Seymour plan. He favors doing enough additional work on the Erie Canal so that a boat loaded to 7 ft. draft could pass through it, which could probably be done for little more than has already been appropriated. If it is attempted to do much more than this and spend $16,000,000 or so, he believes it would be far wiser to co-operate with the General Government and make a radical enlargement of the canal so as to accommodate 1,500-ton barges, on the plan recommended by Major Symons.

SOUND ADVICE TO ENGINEERING GRADUATES.

In a recent address before the Engineering Society of Columbia University, Prof. Francis B. Crocker, President of the American Institute of Electrical Engineers, gives some sound advice to engineering students and graduates. His remarks were especially intended for those seeking to enter the engineering profession after a course in an engineering school; but they incidentally answer queries frequently put to us regarding the comparative advantages of a systematic training in engineering studies and the gathering of this knowledge directly by work in the field, the shop and the drafting room.

Naturally, Prof. Crocker favors a technical training as a necessary preliminary to successful practice in engineering; but the reasons given for this course are sound. While the time consumed in the technical school is seemingly regarded as wasted by some men desiring to become engineers, the difference between the thoroughly trained engineering graduate and the man who has gained all his knowledge in practice, may be briefly stated as follows: The educated engineer has a completeness and clearness of information which can never be otherwise obtained; for, in addition to gaining a special and practically complete knowledge of some one branch of engineering, he is made familiar with all allied subjects, and with his mind scientifically trained he can more rapidly grasp new problems as they present themselves. He is systematically trained in mathematics, physics, chemistry, etc., a class of studies which are so valuable as to be well-nigh indispensable, not only in engineering work, but in business life. Finally, under the training of expert teachers, he gains more actual knowledge in the four years at school than he could possibly gather up in ten years outside.

The man who commences practice without this preliminary and thorough training is handicapped in advancing. He learns the branch of the profession into which he first happens to be thrown, thoroughly, perhaps; but it takes him longer to learn it than it would the graduate from an engineering school. Further, as he learns by actual experience only, he remains ignorant of many other equally important parts of his profession owing to the lack of opportunity to study them. There are serious gaps in his knowledge, which time will not fill up, under the conditions imposed, and he soon finds himself in a rut, from which there is practically no escape.

As to the criticism so frequently heard that a graduate, on leaving college, is not an engineer, and is not capable of performing the work of an engineer, Prof. Crocker answers that the graduate of a first-class technical school, in clearness, completeness and accuracy of his fund of knowledge, is fully the equal to, if not the superior of, the average practicing engineer without such an education. What he lacks is the ability to practically apply his knowledge with the same readiness as the engineer who has had some years of experience; and he is not worth so much in a commercial establishment because he is also lacking in business methods, appreciation of dollars, and is unfamiliar with short cuts and practical ideas that only come with experience.

To obtain this valuable supplemental knowledge, the graduate must, therefore, first secure a position; and in this connection Prof. Crocker imparts some further sound advice. Condensed, this advice is, take the first position that is available and then work hard. Do not make the fatal mistake of waiting for something to turn up; and work for nothing rather than remain idle; for this work and the experience gained is your future capital. Very often, connection with a small enterprise is more profitable than an engagement with a large concern, for the individual is less liable to be lost in the smaller business; and for similar reasons, a small community usually offers better opportunities for experience than the large cities. As Prof. Crocker says, there are few geniuses in the world, and most of these few seem to have a pretty hard time of it; hence, it may be truthfully said that the successful men are men of average intelligence, and their success is simply due to persistent, reasonably intelligent and careful work. Conscientious, intelligent hard work is the key to success in any profession, and engineering is no exception to this rule.

The young engineer should also understand that he must accept responsibility when it is placed upon him, and use it wisely. It is better to make a decision at the risk of a mistake than to do nothing. As responsibilities increase he should take care not to waste time over work that can be more easily and cheaply performed by subordinates. He should not attempt to be an expert in many directions; for few are successful even in one direction, and practically none excel, in several different fields.

One of the important points touched upon in this address, and one that has much to do with the life success of any one, no matter what his vocation, is what may be termed the social element in business. Assuming that the young engineer has average intelligence and that this has been developed by systematic technical training, the possession of tact, or a knowledge of human nature, and the ability to deal successfully with superiors, equals and subordinates, will vastly aid in his advancement. This is a thing that professional education fails to impart; it is usually born in the man, and is difficult to acquire. But it must be considered in an inventory of the qualifications for success; and if a young man is so unfortunate as not to possess it naturally, he should strive to acquire such measure of it as he can, and he must work the harder in other directions to counter-balance the deficiency. An extended acquaintance and the art of making a favorable impression count for much in any professional advancement, and many an able engineer has failed to succeed simply because he was not personally agreeable to subordinates or to superiors.

Briefly summed up, this advice to young engineers stands about as follows: Obtain the most thorough and systematic technical training possible, and then seize the first opportunity that presents itself for obtaining experience, regardless of compensation. With the position obtained, work hard, over hours if necessary, and take the initiative in finding work to do. Experience is what is wanted, and the quicker this is obtained the faster will be the advancement.

As Prof. Crocker remarks, very few men make legitimate fortunes, as fortunes are accounted nowadays, in a life practice of engineering, and from their salaries alone. This profession, however, is so intimately connected with great business enterprises that opportunities do occur for passing from one to the other, and the young man should always keep his eyes open for these opportunities. But here again, hard and faithful work in his profession and the possession of the skill, energy and executive ability that attract the attention of superiors, form the best letters of introduction to the more lucrative positions.

It may also be said to any young man looking forward to engineering as a profession, or as a stepping stone to other employment, that a thorough technical education is now a necessity to anyone who would begin the practice of the profession with hope of attaining a position better than that of a skilled workman. During the past 30 years the advancement in engineering science has been so great, the ability to apply this knowledge in practice has become so requisite, and the opportunities for acquiring a systematic and sound scientific training have been so multiplied, that there is no longer a place for the "practical" or "born" engineer. The systematically-trained engineer will now outstrip him every time in obtaining the honors and awards of the engineering profession. And it is a fallacy to suppose that the "practical" man is better fitted to secure the lucrative outside positions referred to. The reverse is the case, owing to the vastly superior mental equipment and social development of the educated man, and to the fact that these qualities are more appreciated now by the officers of large industrial enterprises than in years past. This increased appreciation is itself the direct result of a broader general education, and of the great improvements that have been made in methods of technical instruction. There are exceptions to all rules, and every one honors the man who has risen to professional eminence despite the lack of educational advantages; but the men who do this are so few and their path to success has usually been such a thorny one, that few would advise the beginner to enter upon it with only the remote possibility of a like success ahead of him.

LETTERS TO THE EDITOR.

Engineering Features of a Proposed New Charter for Baltimore.

Sir: A commission appointed by Mayor Malster is engaged in drafting a new charter for the city of Baltimore. One feature of the draft as it stands at present, which will be interesting to readers of the Engineering News, is the provision that the city engineer, who will replace the city commissioner as at present, must be a civil engineer of five years' actual practice in his profession, and who has been in responsible charge of work that length of time. The city engineer will be president of the board of public works. This board will consist of the city engineer, the engineer of the water board and engineer of the harbor board. A most excellent feature of the proposed charter is the provision that all appropriations carrying money must be passed on by a board of estimates before they are submitted to the council for passage.

Baltimore, Md., Jan. 22, 1898. James A. Paige.

Inspection of Steel for a 30-Story Building.

Sir: In view of the increasing interest taken in "skeleton" steel construction for tall buildings, the following may be of interest to the readers of your paper:

The specifications for the 30-story Park Row building now in course of erection opposite the New York Post Office calls for "medium steel," 60,000 lbs. to 68,000 lbs. ultimate tensile strength, with an elastic limit of not less than half the ultimate strength; a minimum elongation of 20% in a measured length of 8 ins., a minimum reduction of area 40% and to bend cold 180° to a diameter equal to the thickness of the test piece without crack or flaw on the outside of the bent portion.

Up to the date of Dec. 18, 1897, the number of tests made were 890. These were taken from universal plates, sheared plates, angles, and webs and flanges of beams and channels, and are as follows:

Kind of steel.	Accepted.	Rejected.
Basic open-hearth	544	13
Bessemer	326	7
	870	20

The steel was manufactured by the Carnegie Steel Co., of Pittsburg, and the tests were made by Messrs. Hallsted & McNaugher, of Pittsburg and New York.

Yours respectfully, Nathaniel Roberts,
Designing and Consulting Engineer to the Park Row Building.

New York City, Jan. 18, 1898.

Rapid Work in Hydrographic Surveying

Sir: Referring to the article in your issue of Jan. 6 giving "Fast Records in Hydrographic Surveying," I should like to give you the following records which, for fatiguing work, I think are better than the records given by Mr. Cooper. The work was performed by the writer in 1894 during the progress of an extended river survey covering about 120 miles.

The soundings were taken from a large skiff propelled by three picked oarsmen and located by two transitmen at triangulation points on shore. It is worthy of note that the three oarsmen were not relieved during the progress of the work given below. Besides the oarsmen, the skiff's crew consisted of a sounder, recorder and signalman. The signals were located and soundings taken every 15 seconds for the first two days and every 10 seconds for the last two days. The soundings were taken on lines averaging 1,600 ft. in length running across the river. An average time of 1 hour and 38 minutes was lost for dinner each day, necessitating an additional mile of rowing for the oarsmen.

Aug. 24, 1894—Actual time sounding with 2-minute rests between lines for oarsmen, 8 hrs. 44 min. Number of lines run, 65; signals located and soundings taken, 1,705.

Aug. 25, 1894—Time sounding, 8 hrs. 33 min; sounding lines run, 69; signals located and soundings taken, 1,803.

Aug. 27, 1894—Two hours lost on account of fog. Time sounding, 6 hrs. 36 min.; sounding lines run, 45; signals located and soundings taken, 1,696.

Aug. 28, 1894—Time sounding, 8 hrs. 30 min.; sounding lines run, 76; signals located and soundings taken, 2,300.

These soundings were taken on a dangerous patch of bowlders which required that every sounding be located.

Respectfully yours, E. E. Barrett, U. S. Inspector.

U. S. Engineer Office, Burlington, Iowa, Jan. 20, 1898.

A New Theory of Bridge Strains.

Sir: The accompanying clipping was mailed to me by a friend, without comment. I forward it to you in the same condition. Possibly you may want to file it in your Curio Drawer.

Yours truly, Alfred M. Mosscrop.

Rochester, N. Y., Jan. 18, 1898.

(The clipping enclosed is as follows:)

To the Editor of the Brooklyn Eagle:

Will you kindly state whether a train exerts the greater strain on an iron bridge when it is going fast or when it is going slowly. Measure.

Answer—A train always exerts greater strain on an iron bridge when going quickly than when going slowly, but the difference in the strain depends on the structure of the bridge and is much more in some cases than in others. When the train goes over a bridge it causes a wave to travel along the bridge owing to the elasticity of the iron. That part of the bridge just in front of the train is raised a little, and the part under the train is lowered, so that each part of the train goes over it, and the more quickly the train travels the more sudden this will be and consequently the more violent. The strain produced will vary with the square of the velocity of the wave, so that the train will exert four times the strain when it doubles its velocity, nine times when it triples its velocity.

(We also would make no comment on the above except to carry the numerical illustration of the theory a little further. Thus if a train produces a certain strain on the bridge at a speed of one mile per hour, it will produce 100 times as much strain at a speed of 10 miles per hour, and 3,600 times as much strain at a speed of a mile a minute. If "strain" means deformation, as many engineering writers contend, what a warped condition the structure must be in!—Ed.)

The Professional Spirit Among Engineers.

Sir: A communication printed in your issue of Dec. 16 (p. 394), entitled "A Matter of Engineering Ethics," narrates briefly an unpleasant experience of the writer of the article referred to, when as a junior engineer he sought advice and aid from older and established members of the profession.

In it he attempts to "illustrate by one concrete example an absence of any sense of fraternal feeling which must exist to some extent even between the highest senior and the humblest junior," and he contends "that any man of honest purpose" and well prepared for the practice of his profession "is entitled to something more than contemptuous indifference."

For the refreshment of this writer, and so far as may be to prevent other juniors who may have read this communication, from forming wrong conclusions, an "Old Fellow" would recite an experience in his immature callow days. Fresh from graduation, and saturated with the fallacy that the course of training pursued, books and teachers, had endowed him with all professional knowledge, he began the preparation of plans for a local waterworks. He could make the surveys and the consequent general design, including the proportioning of the retaining earth-works and masonry dam, the size of conducting pipes and other important detail, but he knew nothing of the cost of materials or of the work, the style of connections and of valves then deemed best to include, or what make of pumping engine he should recommend. To obtain the requisite information, he addressed a circular letter to the chief engineer of each large waterworks in this country; these were men who were then, singly and collectively, developing and establishing American hydraulic engineering as it has since been—pioneers and masters in their profession, and more than one conspicuously honored because of his achievements.

The circular letter consisted of a large number of questions, each pertinent to the inquiry, and the whole comprising the full information sought. With but one exception, each one addressed fully, and some profusely, replied, giving to a novice and stranger from their abundant store all that he desired. The one excepted, perhaps, conferred the greater favor. He, in kindly spirit, wrote, substantially, that it could hardly be expected of him, busy as he was, to perform for another the work with which he was charged. The lesson, thus pertinently given, was of more worth than chapters of data which perhaps might have been supplied.

These letters have been gratefully preserved for many years. Among the signers are, Chesbrough, Copeland, Graff, Lane and McAlpine; others were their contemporaries—and all have gone to their eternal rest.

Since this early time, during an active engagement in practice—sometimes in private, but longer in public positions—never has a young engineer made clear request of me for advice, information or data, without receiving it; perhaps at my personal cost. And why? For a dutiful as well as a selfish reason. Thereby not only the debt owed to my professional brethren for similar and abundant service was acknowledged, but also the future was fortified against; the time when higher trained, better equipped and more persistent young men shall chase the old fellows from the field of action.

This is perhaps a personal narrative, and as such only, would not have been written; but the experience recorded, covering a period of more than forty years, is not singular to myself; it truthfully reflects what is generally the attitude and disposition of the older to the younger members of the profession of civil engineering.

New York, Jan. 18, 1898. G. Leverich.

Tests of Cast-Iron Columns by the New York Building Department.

Sir: In his answer to mine of Jan. 14, Mr. Ewing fails to state which of the readings were obtained under rising and under falling loads, and he does not state what was the value of the initial or final readings during the Phoenix tests. Thus, while his table of compressions under gage reading 200 (equals 645,400 lbs.) gives a total compression of apparently .0241 (about) the compression under same load at Watertown is reported as about .050 or more than twice as much, which is, of course, an error.

I should now like to state that the tests which you have fully reported were made in accordance with suggestions and on a plan or method made by myself while I was "Special Engineer" in the Department of Buildings. As such I was directed to work up the "Ireland Building case" and determine the cause of collapse. While doing this I discovered that the actual ultimate cause of collapse was the failure of a defective bracket on one of the cast-iron columns in the building; it developed that this bracket was defective because of the bad quality of iron used in the columns. The columns were so full of defects that I suggested to the Superintendent of Buildings that he have some of them tested, in order to develop the complete state of facts.

At the time I also called his attention to the fact that the formulae for calculating the resistance of cast-iron columns, in use at the time in the Department, were totally erroneous.

As I also knew that the Phoenix testing machine required correction for frictional resistance, which had never been determined with sufficient accuracy heretofore (but only approximately by myself), I suggested that a steel column capable of carrying a safe load of 500 tons, which could also be tested in the Emery machine at Watertown Arsenal, Mass., be constructed, and that this column be then used, as was done by myself in October, 1896, and recently by the Department of Buildings in December, 1897.

The Department of Buildings has, however, not seen fit to make public my tests of the standard steel column, of four other Ireland Building columns and their brackets, and a series of filleted and unfilleted bracket-tests, although they would add materially to the value of the tests which you publish.

After having established the very indifferent quality of the iron used in the Ireland Building, and knowing the erroneous character of all commonly used column formulas, I suggested that two 15-in. columns out of the collapsed building and four similar but specially made columns be tested. I then had drawings of these 15-in. columns made and patterns from them. From the latter, two each of strong and of ordinary iron, were cast and these six columns are reported as columns B_2 and B_4, and I. and II., and 5 and 6. Regretting that not all of the information obtained has been made public by the Department of Buildings, I am yours truly, Gus. C. Henning.

220 Broadway, New York City, Jan. 24, 1898.

Sir: From personal observations and notes made at Phoenixville, Pa., during the tests of cast iron columns and brackets by the Department of Buildings of New York, I would like to add a little to what has already been said in your excellent report in the last two issues of Engineering News.

The breaking loads given for columns I., II., III., XV. and XVI. do not indicate the maximum unit loads which these columns sustained, since they failed where the metal was defective, generally near the bottom and not in the middle, where the stress was a maximum. The failure of these five columns shows conclusively that such defects are liable to exist without the least indication of the defects being apparent under a most careful inspection.

Columns B_2, 7, 8 and XVII., on the other hand, failed where the theoretical stress was the greatest and where fractured surfaces of these columns showed no flaw in the metal. In consequence. These four columns would seem to be the only ones in this series of tests which can safely be considered as a basis for the derivation of a new formula for the strength of cast iron columns. The deflections in a horizontal and in a vertical direction, of the middle points of columns 7, 8 and XVII. were observed from the beginning of each test to the breaking point, and are available for computing the exact amount of eccentricity and the maximum stress at the centers. It is worthy of note that the defective columns all sustained a greater average unit load than the sound columns of the same dimensions, showing the great variation in the quality of metal which might reasonably be supposed to be uniform. These tests show that a cast iron column will deflect appreciably long before it reaches its maximum load; for instance, the permanent set in column 5 was 2 5-16 ins. in a distance of 8 ft. 3 ins. Column XVII. began to deflect when it received about one-third of its ultimate load. Yours truly,

F. L. Douglas.

220 Fourth Ave., New York, Jan. 25, 1898.

The Computation of Strains in Coal and Grain Bins.

Sir: In your issue of Dec. 30, Mr. Barton calls attention to an error in my letter, published Nov. 4. The line in question should read, "The intensity of the pressure at C being represented by CF," and not as stated by Mr. Barton, who suggests that it should read, "The intensity of the pressure at E being represented by CF."

The equation,

$$E = \frac{H^2 \gamma}{2} \tan^2\left(45^\circ - \frac{\varphi}{2}\right) \qquad (1)$$

is equivalent to

$$E = \frac{H^2}{2} \gamma \times \frac{1 - \sin \varphi}{1 + \sin \varphi} \qquad (2)$$

since

$$\tan^2 \frac{1}{2}\left(90^\circ - \varphi\right) = \frac{\sin^2 \frac{1}{2}\left(90^\circ - \varphi\right)}{\cos^2 \frac{1}{2}\left(90^\circ - \varphi\right)} = \frac{\frac{1}{2}\left(1 - \cos\left(90^\circ - \varphi\right)\right)}{\frac{1}{2}\left(1 + \cos\left(90^\circ - \varphi\right)\right)}$$

which reduces to $\dfrac{1 - \sin \varphi}{1 + \sin \varphi}$

Equation (2) may be written:

$$E = \frac{H}{2} \cdot H\gamma \frac{1 - \sin \varphi}{1 + \sin \varphi} \qquad (3)$$

Now, if H represents the altitude of a triangle $H\gamma \dfrac{1 - \sin \varphi}{1 + \sin \varphi}$ may represent its base, and the product of this by $\dfrac{H}{2}$ will be the area of the triangle, which would equal E in magnitude.

$H\gamma \dfrac{1 - \sin \varphi}{1 + \sin \varphi}$ is the intensity of the pressure at the depth H, and is equivalent to the equations given by Rankine, Winkler, Mohr and Alexander.

For pressure upon inclined surfaces (surface of material horizontal)

$$E = \frac{H^2 \gamma}{2} \sqrt{\tan^2 \alpha + \left(\frac{1 - \sin \varphi}{1 + \sin \varphi}\right)^2} \qquad (4)$$

where α is the angle of inclination with the vertical. If L represents the length of the inclined plane, measuring from the surface, $L \cos \alpha = H$, and (4) may be written:

$$E = \frac{L}{2} H \cos \alpha \gamma \sqrt{\tan^2 \alpha + \left(\frac{1 - \sin \varphi}{1 + \sin \varphi}\right)^2} \qquad (5)$$

$$H \cos \alpha \gamma \sqrt{\tan^2 \alpha + \left(\frac{1-\sin\varphi}{1+\sin\varphi}\right)^2} \qquad (6)$$

represents the intensity of the pressure at the lowest point of the inclined plane of length L.

Using the data given by Mr. Barton:

$$H = 19.5 \text{ ft.}$$
$$\alpha = 43° 44'.$$
$$\gamma = 58 \text{ lbs.}$$
$$\varphi = 30°.$$

$p = 22$ lbs. nearly, which agrees very well with the value obtained graphically by Mr. Barton, viz.: 830 lbs.

If h represents the depth of some point in the plane of the length L, between the bottom of the plane and the surface, the total pressure upon the upper portion will be found from

$$E = \frac{h^2 \gamma}{2} \sqrt{\tan^2 \alpha + \left(\frac{1-\sin\varphi}{1+\sin\varphi}\right)^2} \qquad (7)$$

The total pressure upon the lower portion of the plane becomes

$$E = E - E = \frac{H^2 - h^2}{2} \gamma \sqrt{\tan^2 \alpha + \left(\frac{1-\sin\varphi}{1+\sin\varphi}\right)^2} \qquad (8)$$

Using Mr. Barton's data,

$$E = \frac{320.16}{2} \times 58\ (1.012) = 9,403 \text{ lbs.}$$

Mr. Barton gives for this 8,307 lbs., through an error in taking the projection of MA instead of the length MA. (Fig. 2, p. 427.)

Equation (4) is thoroughly demonstrated in my book, "Retaining Walls for Earth," as well as many other equations for special cases.

I do not wish to convey the impression that my equations and methods are necessarily correct for coal and grain, but under the assumption that the mass is granular and without cohesion, I believe the equations and methods exact.

Without entering your pages in controversy, I am ready to rigidly demonstrate for any one any of the equations presented, upon being requested to do so.

Yours very truly, Malverd A. Howe.

Terre Haute, Ind., Jan. 3, 1898.

Tests of Two Fire Engines at Philadelphia.

Sir: Public comment on the relative efficiencies of the two types of fire engines used by the Philadelphia Fire Department at the recent fire in the Dobson Building urged Mr. Baxter, the Chief Engineer of the Fire Department, to suggest to the Director of the Department of Public Safety to have a comparative test made between the piston-engine and the rotary engine, these being the two classes of engines in use in the Fire Department. Accordingly, a committee of experts was appointed to conduct these tests, for which Chief Baxter recommended the following specifications:

(1) That they draw water from separate plugs, and their force, height and volume of water be tested; that they likewise be made to draw from the same plug and the powers tested. (2) That a test be placed at a point where they have to draw water from the river. (3) That a test be made with a lead of 600 ft. and also a lead of 1,500 ft. of hose, and that at some part of the exhibition the nozzle be raised to a point in the air as when attending fires in high buildings. Also the weight of both types of engines. Also continuous service for five or six hours.

The engines used as representatives of their respective types are said to have been selected at random; neither one was allowed any preparation for this special work that it was to perform. They were selected on the morning of the test, hauled from their respective houses to the place at which the test was to be conducted and put into service.

In selecting representative units of quantities it must be remembered that each unit so selected should be a fair representative of the whole. The piston engine which was used can hardly be said to have been a good representative of its class, it not being, however, the fault of the engine, but a mistake on the part of those who chose the apparatus.

The engine was quite old; it had seen many years of service, and, as was found when making the tests at the river, it was greatly in need of repairs, so much so that the experts refused to continue the test and declined to make a report on what results had been obtained. On the other hand the rotary engine was almost new, and is reported to have been in active service less than one hundred hours. A machine must indeed be very efficient to compare favorably with its rival under such conditions.

In making a test for comparison of apparatus it is necessary to have all the conditions at the start and throughout the test absolutely and not apparently equal, and, so that the results from the tests of these engines could have been compared, they should have undergone a thorough examination and each placed in its best working condition regardless of what amount of repairs would have been necessary.

The specifications require the measurement of the force, height and volume of the water pumped by each engine. It is true that observations were made to determine these quantities, but whether the results obtained from each engine could have withstood fair comparison is questionable. The data taken to compute the volume of water pumped were the pressure of the water at the pump and the area of the opening in the nozzle. Every one who has had any experience with steam and water pressure gages knows how unreliable, even when comparatively new, are the readings obtained from these instruments and how much more so they would be after having been in service a number of years. From reliable information it was learned that neither steam nor water gages had been tested or calibrated.

Again, in assuming coefficients of friction for the water being pumped through sections of 1,500 ft. of hose, there is liable to be an error, since it is hardly possible to lay two sections of hose of that length approximately alike with respect to bends and turns unless they are laid parallel with each other, which was not the case in this test; in fact, they were each run on different streets, and a fair comparison of their relative conditions could hardly be made.

The question arises as to the horse-power being developed to do the work. No reliable test was made to determine this very important factor. Perhaps the diameter of the cylinder, the length of the stroke, number of revolutions, etc., may have been determined, but "calculated horse-power" and "indicated horse-power" vary too widely to substitute one for the other. No engine can be fairly tested for efficiency unless the "indicated horse-power" be obtained. On what were the powers of these engines based. Pumping water from the same plug will show which engine can throw a stream of water under the same head a greater distance, but if there is more energy being put in one engine than in the other what else could be expected than that the one should do better than the other? Efficiency being the ratio of useful work to work expended, it can hardly be supposed that the "calculated horse-power" could represent the amount of work expended at the same time, neither could it be relied upon, since from the very start it was not determined how accurate the steam pressure gage was. The useful work is again an assumption based on a water pressure gage of unknown reliability, an an assumed coefficient of friction.

If fire engines now manufactured do not have the necessary openings in the cylinders for indicator attachments it seems to be advisable to have them made. Municipalities should not make tests on their engines every nine or ten years, but frequently and at least before the apparatus is accepted from the manufacturer. The engines should be purchased subject to a guarantee of efficiency, and a test to determine the fulfilment of the contract should be conducted, but with some modifications, similar to the tests for the efficiency of other steam engines.

The comparative test resulting so unsatisfactorily, there does not appear to have been much definite information gained from the committee's report, aside from the fact that the rotary engine had every advantage; and at the most, all the knowledge that could have been gained would have been that under conditions in some respects apparently similar, the piston engine accomplished one thing, the rotary another.

Edwin S. Boyer,
Jun. Am. Soc. M. E.

Philadelphia, Pa., Jan. 15, 1898.

Widening the Gage of Railway Track on Curves.

Sir: In replying to your letter of Oct. 19, in which I have been unavoidably delayed, I would say that when I hurriedly answered the inquiry of the American Railway Association, as to the practice of this company in the matter of widening the gage of track on curves, I was governed by recollections of experiences of some 30 years ago, when in direct charge of construction and maintenance of way matters, and when comparatively light and short engines were in use.

I am pleased that this inquiry has been started, as the diversity of views entertained, as shown by the replies of the different roads, and your inquiry, have led me to make investigations through our Engineer and Road Departments, which would seem to go to show that if provision is not made by the tracklayer, the equipment will undertake the matter on its own account, and in spite of rail braces, double-spiking, etc., will pretty soon substitute a 4 ft. 9 ins. to a 4 ft. 9¼ ins. for the 4 ft. 8½ ins. gage on our sharpest curves; that is, will widen the gage from ½ to ¾-in. Just how much of this is chargeable to engines, and how much to foreign cars which are gaged too wide, I am unable to answer.

Our longest ten-wheel and consolidation engines have wheel bases as follows: Ten-wheeler, rigid 13 ft. 6 ins., total 24 ft. 6½ ins.; consolidation, rigid 14 ft. 10 ins.; total 22 ft. 8 ins.; standard consolidation, rigid 14 ft., total 21 ft. 6 ins. All engines of more than four drivers have front and back drivers flanged and intermediate drivers flat, and all engine trucks have swing centers, whether two or four-wheeled. We are of the opinion that trucks with rigid centers—that is, with swivel motion only—would not perform satisfactorily upon such a crooked road as the Western Maryland.

Unfortunately for this road, most of its sharp curves occur upon mountain or other sections, where low speed in one direction is enforced by heavy grades, hence the natural conclusion is that the widening of such curves by the pushing out of the inner rail has resulted from too much elevation for up-grade movements, but this would not seem to account for the widening, as such a conclusion is negatived by the testimony that when the gage has been widened from ¼ to ¾-in., according to the degree of curve, the spreading has stopped, so that tests made after long lapses of time fail to show any further change.

While from the above, the widening of gage on sharp curves would seem to be wise, indeed necessary, it is clear that where switches occur upon such curves, the guard rails should be adjusted to suit the distance between wheel flanges, with a reasonable allowance for play; that is, they should be placed the same distance from frogs as upon other curves and straight lines. The enclosures from Engineer Vandevanter and Roadmaster Straw, giving actual experiences upon the subject of widening gage for sharp curves, will, I believe, prove of interest.

Yours truly, J. M. Hood,
General Manager, Western Maryland R. R.

Baltimore, Md., Jan. 14, 1898.

(The enclosures mentioned by Mr. Hood are printed herewith.—Ed.)

Sir: I have been unable to reply sooner to your inquiry upon the subject of widening the gage on curves. I have never studied this subject systematically, and my opinion was that theoretically it was wrong. I concluded, however, before answering your inquiry, to investigate just what foremen were doing on the road.

I have obtained reports from Supervisors Wade and Martz on their experiences on the Second and Third Divisions, and they both report that they find if the gage is not widened on sharp curves that it is impossible to keep the rails to place; that the engines will themselves push the rails back. Mr. Wade writes me:

I examined several of the sharp curves on section 20 to-day, and found four of the 7° curves as follows: One that was respiked in October last had spread ¼-in.; the second curve had spread from ¼ to ½-in., and the two curves east of the big trestle from ¼ to ¾-in. The two 8° curves at Stoner's, on the west end of section 20, generally spread in a few weeks after they are remodeled from ¾ to ⅞-in., and stay at that so long as the ties are in a fair condition.

Mr. Martz reports that when he was foreman of section No. 4 he had a great deal of trouble with the 9° curves at the crossing of the Gunpowder River, as long as he tried to keep them to 4 ft. 8½ ins. gage, but he finally spiked them to 4 ft. 8⅞ ins., and since that time has had no trouble, and they are now at that gage by recent measurement. He thinks a 4 ft. 9 ins. gage would be still better on these curves. He says when the connection was made at Hoffman they had trouble with that curve continually until he spiked it at 4 ft. 9 ins. gage, after which they had no further trouble.

If it is true, as seems to be the case from the reports given above, and from what Roadmaster Straw says, that a track cannot be kept at 4 ft. 8½ ins. gage around sharp curves, it would seem to be not only good policy, but a necessity to widen the gage; and the only question remaining is to determine how much. I am not prepared to pit theory against facts, though I confess I am surprised.

Very respectfully,
C. O. Vandevanter,
Prin. Asst. Engineer, Western Maryland R. R.

Baltimore, Md., Nov. 23, 1897.

Sir: In obedience to your request of Nov. 6, relative to our views as to the advisability of widening the gage of track on curves, I prefer to recite my experience in this direction rather than to express my views.

Until some four or five years ago we had constant complaint that the 10° curve immediately west of Bridge No. 97 and the 9° curve just east of same bridge could not be kept from spreading and canting the inner or low rail outward. We directed the foreman to spike these curves to a gage of 4 ft. 8¾ ins., since which time there has been no trouble with them. In the case of the 10° curve on east branch of the Y at Hagerstown, while the track was spiked to neat standard gage, 4 ft. 8½ ins., the best quality of crossties could not be made to last over three years, even when protected by tie plates; the inner or low rail being forced and canted outward and tie plates in many cases being worn and broken under the outer edge of the rail, so that we could not maintain a gage of less than 4 ft. 9 ins., no matter how often we respiked and brought the track to 4 ft. 8½ ins. gage. Rail braces seemed to have little or no effect in preventing the spread.

About nine months ago we overhauled this curve and put new tie plates under the inner rail and spiked it to 4 ft. 9 ins. gage (a special gage being provided), and upon receipt of your inquiry I directed the foreman to make a thorough examination of the present condition of this curve, particularly as to gage, and had him come to this office this morning, when he stated that he has had no trouble with it since it has been spiked to the 4 ft. 9 ins. gage, and that upon trial yesterday with this gage he found it intact, except at a few points, where a spread of less than ¼-in. seemed to have taken place.

I would further state, that having re-run nearly all of the sharp curves on the main line, as well as some half dozen on the Baltimore & Cumberland Valley R. R., I

found in every case, except where the ties had been renewed and the track respiked a short time before, that the track was spread from ¼ to ½-in., and the foreman declared that however often he might correct this, a few days' service would again spread it more or less, according to the degree of curvature. All these experiences indicate to me that the rolling stock requires this additional width of gage on sharp curves, and if it is not already provided in spiking the track it will provide it for itself.

As to providing for guard rails, where these occur on widened curves, we place the guard rail so that the distance between wear side of wing-rail of frog and wear side of guard rail equals the standard distance allowed between inner faces of wheel flanges, less ¼-in. for play.

Very respectfully, W. R. Straw, Roadmaster.

Union Bridge, Md., Nov. 11, 1897.

Some Experiments on the Pressure of Stored Grain.

Sir: It appears that some experiments on the pressure of stored grain, made about 15 years ago in England, have been entirely overlooked in the recent discussion in the columns of Engineering News, or if known to the editor or others engaged in the discussion, that their significance has been underestimated. The experiments referred to were made by Isaac Roberts, F. G. S., F. R. A. S., who described them in a paper before Section G of the British Association for the Advancement of Science at its meeting in 1882 at Southampton. The report of the British Association for that year does not give the paper in full, but abstracts it as follows (p. 678):

The author gave an account of certain experiments carried out by him with the view of ascertaining the pressure on the bottom of the tall bins in which corn is frequently stored. The result of these experiments showed that after the corn had reached a certain height in the bin, the weight of any further additions was taken by the sides of the bin and caused no increased pressure on the bottom.

Apparently the value of a detailed description of these experiments was appreciated more by the editor of an American technical journal than by the editor of the annual report from which the above meager abstract is quoted, for a full reprint of the paper appears in Engineering News, Vol. X., pp. 158-9 (April 7, 1883). As this volume is probably not available to some who are following this discussion, the essential features of the paper will be quoted. After referring to the American practice of storing grain in "bins measuring from 10 to 12 ft. square, and from 50 to 80 ft. in height," Roberts refers to the uncertain basis for the design of the walls of these bins in the following language:

One great difficulty in designing buildings to store grain in is the absence of data by which the strength of the partitions and external walls which form the cells can be computed. Any data founded on the rules applicable to hydraulics will not apply, nor will rules applicable to sand or gravel apply, as the friction among the particles and difference in the specific gravity would give inaccurate results. Hence, the experiments which I will now describe have been undertaken to afford data which may indicate with more or less accuracy the pressure upon a unit of surface exerted by wheat when stored in elongated cells.

The accompanying table gives the dimensions of the four cells used by Roberts in his experiments, and also the principal data observed in the series. The tests with cell No. 1 gave such unexpected results that the other three were made and the series was completed with the same care throughout. The cell was supported firmly by three legs and the weighing was done by means of a false bottom, a thin board, which rested "upon a weighing machine and counterpoised so as just to touch the bottom of the cell when placed in position; half an ounce weight on the board could be indicated by the machine." The following description of the tests with the first cell is typical of the others:

The wheat was measured into the cell in imperial gallons and quarts, one gallon weighing 7.8 lbs. The weighing machine was weighted with 56 lbs., and after the given quantity of wheat had been measured into the cell, the weights were removed half a pound at a time, till the machine indicated the pressure upon the movable bottom of the cell, within the limit of half a pound weight. One gallon of wheat poured into the cell measured 6¼ ins. in height, and indicated a pressure of 5½ lbs. on the bottom; 2 gallons, 12½ ins. in height, pressure 7½ lbs. From 2 gallons up to and including 9 gallons, or from 12½ to 56 ins. in height, no increase in the pressure beyond 7½ lbs. was indicated, though 9 gallons of wheat weighing 70.2 lbs. were put into it. Twenty-six separate weighings were made with various quantities of wheat from 2 to 10 gallons, and in no instance was the minimum pressure below 6 lbs., nor the maximum above 7½ lbs.

The discussion of the results of the experiments is somewhat involved, and conclusions reached by the author of the paper, while possibly correct, do not seem to be fully established by the limited tests embodied in the investigation. For example, he discusses the form of the "plug" of wheat which produces the pressure on the base as follows:

It will be observed that all pressure upon the bottom ceases before the cells respectively are half filled with wheat. (This sentence is misleading and erroneous as it stands; the author probably meant to say "all increase of pressure," instead of "all pressure."—W. D. P.) That the highest point within the cell where the (increase of) pressure ceases does not form the apex of a cone, having the diameter of the inscribed circle as its base, is evident, but the wheat must form either a parabola or hyperbola (evidently meaning "paraboloid" and "hyperboloid."—W. D. P.) with that base, and the whole weight of the wheat that may be filled into the cell, excepting only the parabol (oid) or hyperbol (oid), is supported by friction against the sides, and the friction of the individual grains against each other. They form a self-supporting dome out of a plug of wheat held in position by friction. This generalization is borne out by each of the cells, whether it be large or small.

The most interesting feature of the experiments is the relation shown to exist between the diameter of the inscribed circle and the mean height of the "plug" which is supported by the bottom of the cell. The author's formula is as follows:

$$P = A\ C\ D\ W = 1.03\ A\ D\ W$$

or

$$\frac{P}{A} = C\ D\ W = 1.03\ D\ W$$

where P is the pressure in pounds upon the bottom of the cell, A the area of the bottom in square feet, D the diameter of the inscribed circle in feet, C a constant found in the experiments to be 1.03, and W the weight of a cubic foot of wheat, equal to 48.6 lbs. in these tests.

The last column of the table shows the computed results by the above formula. The author does not state the four values of the constant, but a reduction of the data shows them to be as follows: 0.824, 0.882, 1.099, and 1.028, respectively. The mean of the four is 0.96, so that the value selected for the formula is based chiefly on that obtained with the largest cell, No. 4. Commenting on the differences between the computed and observed weights, the author says, at the conclusion of the paper:

The differences between the computed and actual weights are within the limits of divergence that must always remain with wheat, for it is itself variable in specific gravity, in size of grains, in adhesiveness among the grains, and in the quantity of moisture that is occluded.

Had the wheat been lighter, other conditions being the same, the observed pressures on the bottom of the cells would have been less in proportion. With the weight of 48.2 lbs. per cu. ft., as given in Fig. 1, on p. 428 of the issue of Dec. 30, ultimo, the pressures would have been somewhat over 1% less, and in view of the variation of the values of the coefficient above stated, it seems consistent to adopt the even value 1.00, making the formula,

$$P = D\ A\ W.$$

Expressed in words, this formula, in its general application, means that the maximum pressure that can come upon the bottom of a bin of wheat is equal to the weight of a prism of wheat with a base equal to the bottom of the bin, and altitude equal to the diameter of the inscribed circle. The value of the coefficient would, of course, vary with the character of the surface of the sides of the bin, being greater for smooth than rough surfaces. Roberts' paper fails to describe the character of the inner surface of the cells used by him, but as the effect of the friction was very obvious, and he was attempting to deduce a formula for use in actual design, it is fair to suppose that he sought to reproduce the conditions of actual practice. It is apparent, however, that different values of the coefficient should be employed for the roughly built timber bin and the smooth metal cylinder. The demand for more experiments covering a wider range, both as to size and kind of bin, and including lateral pressures against the walls of the bin as well as the bottom pressure, is very evident.

Although this communication was prepared primarily for the purpose of presenting the foregoing matter relative to the Roberts' experiments, the writer desires also to refer to a couple of statements which appeared in the discussion of the question of pressures of stored grain in the issue of Dec. 30, and which seem to bear an important relation to these experiments. The first of these statements is by Horatio A. Foster, of Buffalo, N. Y., and relates to the manner in which grain bins are said usually to fail:

It is found in practice that bins burst oftenest at one-third their height from the bottom, which to a certain extent disposes of any hydraulic theory of pressures as applied to grains. . . . . My only evidence in support of the statement that bins generally burst at one-third their height is, first, the bursting of one here very recently at that point; second, the testimony of the Superintendent of one of the oldest elevators in this town.

The other statement, by the editor, on p. 428, near the middle of the first column, describes a striking instance of vertical compression of the walls of a timber grain elevator bin upon being filled:

With a mass of grain in the bin, however, the pressure upon the bottom is no longer equal to the total weight of the contents of the bin, for there is considerable friction between the material and the sides, so that the sides carry some of the load. In the case of a large grain elevator built under the direction of a member of the staff of this journal some years ago, bins similar in shape to those shown in Fig. 1, but some 75 or 80 ft. deep, had the sides so compressed by the friction of the grain against them as the bins were filled, that the top of the sides was over a foot lower when the bin was filled than when it was empty.

Referring to the latter quotation first, it would be exceedingly interesting to know what proportion of the load actually came upon the walls of the bin through the action of friction. Unfortunately, it is impossible to determine how much of the depression noticed at the top of the bin was due to the compression of the timber and how much to the pressing together of the rough lumber which formed the walls. If the bin were 80 ft. high, there would be perhaps 500 thicknesses of commercial 2-in. plank, and the compression per thickness of plank for the total of "over a foot," stated in the above quotation, would be about 1-40th in. If Roberts' formula is applicable to this case, and the even value above suggested for the coefficient be used, the load coming on the bottom direct is the weight of a 10-ft. cube of wheat, or say 48,000 lbs., and the remainder of the load, equal to 337,400 lbs., is carried by the sides of the bin by friction. If the walls were made of 6-in. plank the horizontal section was about 3,000 sq. ins. and the average load on the timber due to the wheat borne by the sides in this manner would be between 50 and 60 lbs. per sq. in. Referring to the government tests of timber indentation given in the report of the Watertown Arsenal Tests for 1883, it is found that the load just computed is far less than would account for the observed compression of white pine, so that it must be concluded that the movement was due chiefly to the closing up of the spaces between the planks.

Turning now to the statement by Mr. Foster concerning the mode of failure of grain bins, the generalization above quoted from Roberts' paper has suggested to the writer that possibly there is in a grain bin something like the thrust of an arch or dome and that this may account for the failure not far from the bottom of the bin. The impression above quoted as to the usual point of failure can hardly be accepted as final without ample proof to sustain it, nor, on the other hand, should it be rejected without testing its credibility in the light of a special investigation. The writer of this communication proposes to investigate this subject along lines somewhat similar to those pursued recently in an investigation of stand-pipe accidents and failures. Should the results of the inquiry lead to definite conclusions, the same will be made public in due time. Yours very truly,

Urbana, Ill., Jan. 10, 1898. W. D. Pence.

Concerning Erie Canal Improvements.

Sir: In your leading editorial of your Jan. 6th issue you comment upon the condition and prospects of the Erie Canal improvement, and define your position respecting further improvements in water transportation between the Great Lakes and the Hudson and Ohio Rivers. Is it too late to offer some comments prepared in my first spare moments since that date?

It was not to be expected that a journal such as yours would join those who criticize the State officers unintelligently, and in too many cases intemperately, because the cost of the State Canal improvement exceeds the appropriation. Your remarks in this connection are most apposite and judicious. Those who are familiar with all the facts know that the bill appropriating nine million dollars was prepared, introduced, and became a law before the appointment of the present Superintendent of Public Works and without consultation with the State Engineer; that it was drawn to make the prosecution of the work mandatory. It leaves the State Officers no discretion as to whether they shall or shall not spend the nine million dollars. The drafters of the bill made sure of that and of the benefits which such an expenditure would bring. They know also that no real estimate of the cost of the canal work was completed until last September, and that the estimate then made up was nearly the same as the figures with which the public have since become familiar. The assumption that there was a prior estimate supposed to be reliable is baseless. Intelligent persons must recognize that no engineer can make an estimate as to cost of remodelling a work which was covered up by water in summer, and by snow and ice in winter, and of which there existed no reliable record as to its original condition and which had not been uncovered since it was put in place over fifty years ago.

It may not be out of place, in this connection, for me to state my personal opinion and knowledge respecting the State Engineer, Mr. Adams and his staff. I doubt not that the general opinion is that Mr. Adams is a model State Officer; capable, zealous, laborious and self-sacrificing; and conscientious to the point of Quixotism. His is a case of "willing horse," and because he is willing, duties of many kinds have been laid upon him, until the de-

Tabulated Description of Experiments made by Isaac Roberts, to Determine Pressures on the Bottoms of Elongated Bins Containing Wheat.

	Description of the cells						Data observed in experiments with the four cells					
		Horizontal section of cell.						Mean height where pressure on bottom came fixd.	Observed pressures on bottom, lbs.			Pressures computed from the formula, P = 1.03 A. D. W., lbs.
No. of cell.	Form.	Side, ins.	Area, sq.ins.	Diam. inscrbd circle, ins.	Height, ins.	Capacity, lbs.	No. of weighings in series.		Minimum.	Maximum.	Mean.	
1	Hexagonal.	4	41.57	7	60	70.2	26	12½	6	7.5	6.75	8.44
2	Square. . . .	7	49.00	7	36	46.8	17	11	7.5	9.5	8.5	9.7
3	Hexagonal.	6⅞	122.80	12	60	202.8	18	24	41.5	49.5	45.5	42.83
4	Hexagonal.	12	374.11	20¾	96	1,014.0	19	36	211	238	224.5	225.8

mands upon his time and attention are greater than could be discharged by any man without breaking him down, and require an amount of traveling which severely taxes his vitality. He is fortunate in his Chief of Staff, Mr. Herschel Roberts. The two men fit into and supplement one another, and work together in a very exceptional manner. The one is cautious and conservative; the other is ardent and enthusiastic. Their office came to them with a poor organization and defective and ill-kept records. The canal work has been patched up and pieced out without record being kept of what was done, and such records of changes as were kept were not connected with the original record. Along with the necessity of keeping the canals running and of preparing for their improvement, they were obliged to entirely reorganize the office and the system of keeping its records. Only those who have themselves been through such an ordeal know how severe it is.

The Superintendent of Public Works, Mr. Aldridge, was appointed nearly a year after the law was passed. His first act was eminently judicious and flattering to the engineering profession. He attached to himself, as professional adviser, Mr. J. Nelson Tubbs, whose labors were highly appreciated by those who have come into contact with the State officers, and doubtless by Mr. Aldridge himself.

With respect to the contracts already let, those who have followed the bidding know that the prices rule extremely low and that many of the contractors will lose money. The proposition to inflict further loss upon the contractors and to really punish them, and in many cases ruin them by suspending the work after they had provided the necessary plant on the ground, and had purchased their materials, can only be characterized as wicked; and every business man must approve the stand taken by the Canal Board, that the contracts already let must be completed. This proposition was a mere political bid for the approval of the ignorant and unthinking.

As to the work not yet provided for, a great part of it is the improvement of the locks and other structures, and your assumption that the improved appliances for towing, handling boats, et cetera, are not provided for, is unwarranted. I can speak on this subject with greater authority than any other person excepting the State officers. The improvements of this kind in contemplation are high-lift steel locks, which will replace the existing stone locks where they are so concentrated that the lift of several locks can be put into a single structure. There are only five such places on the Erie Canal; namely, two at Cohoes, and one each at Little Falls, Newark and Lockport. In all these together it is possible to consolidate 30 locks into 5. The proposed improvement of the remaining 40 stone locks does not involve any extension of their foundations, or material alteration of their walls; the proposal being to substitute quadrant gates for the miter sill gates, and 8-ft. balance sluices for the present butterfly valves, and to feed and empty them at the side instead of at the ends; the waste space between the lock walls being utilized for feeding and emptying conduits. The apparatus for towing in the boats is included and cuts a very small figure, as it consists, for each pair of locks, in one small turbine wheel, two vertical capstans and six guide rollers secured to the lock coping. When these improvements are completed, if they are carried out on the scale now contemplated, a barge 24 ft. wide, 12 ft. draft and 240 ft. long, carrying 1,500 tons, can pass the Lockport locks. If the level between Lockport and Rochester were deepened to 12 ft. such barges could go to Rochester and that city would have water communication with Lake Erie, on a scale almost equal to and certainly cheaper and more rapid than that afforded to Lake Ontario ports by the Welland canal. The reason for making the Lockport locks of such size was owing to the fact that with the pneumatic lock the difference in cost was small between locks of such dimensions and the 10×20 locks, the dimension considered for other plans, and the great benefit to the interior of New York State, especially the prospect of building up a large trade in transit to the Susquehanna Valley, was thought to amply justify the few thousand dollars which the increased size added to the estimates. It is pertinent in passing to say that the law governing the ratio of increase of cost to increase of size in pneumatic locks is much more favorable to large dimensions than is true of any other device for the purpose.

It has not been calculated to widen the remaining stone locks, as the necessary expenditure was deemed without the province of the law. The improvements in contemplation, however, will increase the possible length of the barges from 98 to 120 ft., and their tonnage from 240 to 410 tons; and as two boats can then pass all the locks without uncoupling, the transportation unit will be increased from 480 to 820 tons, nearly 70%. With such enlarged units it will be economical to make the boats of steel and to propel them by steam, and the wooden boat drawn by mules will doubtless become a thing of the past. With the present size, steel boats are not advantageous. Those now running on the canal weigh more and carry less than the wooden boats, and are engined five times as heavily, so that they depend for their living on avoiding the port and rehandling charges at Buffalo. In view of these facts, and further of the facts that the falling off in canal tonnage is in but little greater ratio than the general falling off in railroad freights, it is to be expected that when the present improvement is completed the traffic of the canals will increase steadily until its volume exceeds anything in their past history. It is worthy of note that canal boat grain is worth more in New York harbor than railroad grain, and that no matter what other and cheaper facilities are made, a certain amount of traffic will go through the canals on account of the facility with which the barges can be unloaded into steamers in this port. It is true that the profits of the boatmen have been insignificant, but the situation has been peculiar in this, that frequently the difference in price in this port between canal boat grain and railroad grain has been equal, or nearly equal, to the price paid for transporting it from Buffalo to New York. The boatmen being poor and without organization are ground between the mill stones of port charges and commissions on one side, and their necessities on the other.

new experience with Government transportation works.

You draw attention to the fact that after the improvement is completed the cost to the State will about equal the transportation charges of the boatmen. This is no

An even more striking example is found in the Canadian canals, the competition of which was the spur to the improvement of the Erie Canal. The question, as it seems to me, is not whether the State pays more or less to bring the traffic to New York, but whether the traffic is brought here at all. This traffic is ardently competed for. The Canadian Government is determined to get it. When the Canadian system of canals is completed the Canadian Government and municipalities will have spent upward of $82,000,000 to open the St. Lawrence route on a 14-ft. scale and to bring the ocean commerce to Montreal. The Canadian canals carry about 1,000,000 tons per year. Half of this is United States commerce in transit through the Welland Canal to Lake Ontario and St. Lawrence River ports in New York State, so that the Canadian commerce through her canals, excluding the Ottawa River lumber, is approximately 500,000 tons per year. The interest on the investment, at 3% will be $2,460,000 per year. The cost of maintaining and operating the canals over and above revenue somewhat exceeds $250,000 a year, so that in round numbers the Dominion of Canada pays $2,750,000 per year in interest and maintenance for canals which carry 500,000 tons of Canadian commerce. Canada pays in interest more to carry a ton of freight through her canals than would carry it on a railroad parallel to them. If the question went no deeper than merely the present most economical handling of the unit of transportation, further expenditures on her canals would be laughable. This adds point, if that were necessary, to your comments on volume of trade. If the volume of trade through the Canadian canals increases when the 14-ft. scale is completed, to anything like their capacity, they will become a source of great wealth and profit to the Dominion, and every dollar of the traffic which they win will be taken away from our volume of trade. On the other hand, if the present improvement of New York State canals does all that its friends expect it to do, the designs of Canada on American commerce will be frustrated and her canals will remain what they are to-day, a terrible burden on her finances and a handicap upon her progress.

I must take exception to your statement that "the ship canal idea is rapidly waning in popularity." Is it not rather true that the general public has suspended its decision pending the Report of the Board of Engineers on Deep Waterways which is investigating the matter by United State authority? The high standing of the members of the Board insures a report of which the profession can be proud, which will treat the subject comprehensively, consider all possible routes and give due weight to recent engineering progress.

The cause cannot be said to lose ground when it gains the support of our leading engineering publication, to wit, Engineering News. In the closing paragraph of your editorial you say: "It appears to us, however, that the projects for free waterways of 12 to 15 ft. depth"—"connecting the Great Lakes with the Ohio and with the Hudson"—"have much to recommend them." Developing the implicit functions of this language, as led up to and elucidated by your prior editorial utterances, it is not too much to say that Engineering News declares in favor of canals, and especially of a canal to connect the Hudson River with Lake Erie, planned and built in accordance with the best modern practice, to accommodate traffic in fleets of towed barges, 15-ft. draft. This implies locks long enough to accommodate at least two barges; locks not less than 600, preferably 650 ft. long. The best of the Lake freighters have beam about three times their draft. The best practice would make the width of the lock three to three and three-quarter times its draft. (The Canadian ratio of width to draft is 3 21-100. Major Symons proposes 3 to 1.) This implies locks 48 to 50 ft. wide. The derived lock dimensions are 15-ft. draft, not less than 48 ft. wide and 600 ft. long. The barges would be about 15 ft. draft, 45 ft. beam, 675 sq. ft. cross section. The canal prism should not be less than 4½ times the cross section of the barge, or 3,037.5 sq. ft. Some authorities say six times, which would give the prism 4,050 sq. ft. There should be several feet under the keels, so that the barges will steer. Either of three canal prisms might be considered to meet the case:

1. Side slopes 2 to 1, draft 18 ft., bottom width 133 ft., top 205 ft., prism 3,042 sq. ft.

2. Side slopes 1½ to 1, draft 20 ft., bottom width 122 ft., top 182 ft., prism 3,040 sq. ft.

3. Side slopes 2 to 1, draft 20 ft., bottom width 117 ft., top width 187 ft., prism 3,040 sq. ft.

Smaller prisms would doubtless make navigation too slow and difficult to be profitable. You term such a 15-ft. canal a barge canal, because you believe the freight would be towed in barges. But it would be a good enough ship canal for nearly all the coasting vessels and for nineteen-twentieths of the lake steamers; for all those built prior to 1894; those which lowered the cost of lake transportation to four-tenths of a mill per ton-mile.

To deepen the locks 3 ft. and widen them 10 ft., would provide ample room for any freighter which can do business on the Great Lakes for the next ten or fifteen years, or until the ports are reorganized. If the canal were equipped with pneumatic locks such an enlargement of them would add about 10% to their cost, and would be profitable, especially for the barges which would undoubtedly use them. If such a canal can be built we can safely leave to forwarders the question of towed barges vs. self-propelling ships.

I would be the last person to oppose such a project, even though I believe another to be better and cheaper. It would have many and great advantages and would be a great boon to all classes of people and kinds of business; would enable the Hudson Valley to engage in heavy manufacturing; save the New England manufacturers, who are being crowded out by high freight rates; give an adequate outlet to the Great Lakes, permanently locate the world's steel-making supremacy on their shores and give the United States primacy in the world's commerce.

But it must be a Governmental work. Private enterprise cannot touch it, because of its great cost, and, therefore, I cannot advocate it until I am convinced that the St. Lawrence-Champlain route cannot be opened by private enterprise. With your permission, however, I will aid the cause by pointing out that the project is free from the limitations which you cite as preventing its construction. The general Government can build it without purchasing the Erie Canal or materially interfering with it. Indeed, to connect such a work with the Erie Canal would greatly impair its usefulness and enhance its cost, and to attempt to carry it through the populous cities which stud the line of the Erie Canal would bring on interference between street and canal traffic which would be intolerable to both. The only part of the Erie Canal system which would have a value for such a work would be its water supply. But the cities and towns need this water and every year the strife for it between them and the State becomes more acute. The local supply at best would be inadequate. Lake Erie must furnish the water. If the canal were made a down grade, which would involve a deep cut many miles long from the Seneca to the Mohawk Valley, and the banks and bottom could be made tight, the water supply problem would be solved. If it were carried over the Rome summit, the water must be brought from Lake Erie in a steel pipe, which is practicable, as the available head is about 150 ft. From Lake Erie to Rome the location should be south of the Erie Canal. Leaving the Niagara River and going up Tonawanda Creek it would pass Pendleton, where the Erie Canal diverges and follow the Creek nearly to Oak Orchard Feeder; there pierce the escarpment and descend to the Rochester level, which should be south of and on a higher contour than the Erie Canal and cross the Genesee River to the south of Rochester. To cross to the north, below the falls, would require an aqueduct over 100 ft. above the river, and deep foundation work in alluvium for the piers. The line should then cut the divide to the Clyde Valley, descend to and follow the Clyde and Seneca Rivers to the point of divergence to the Mohawk, cut or climb the divide into the Mohawk River and follow it, with some rectification, to tide water. The crossings of the Erie Canal would probably be, one in the Clyde Valley and three in the Mohawk, which could be easily provided for by locks, or by a canal ferry.

I firmly believe a great canal will ultimately be built along this line; but not the first great canal between the lakes and the Hudson. If the location of the first canal be decided by engineering and financial considerations, it will follow the St. Lawrence-Champlain route, which can be opened by private capital on a dividend paying basis, with the tonnage which Major Symons, in his valuable report, has proven to be in sight. But engineering and financial considerations may be set aside and wholly different factors may decide the issue. In that event the question would lie between your project and the Ontario-Oneida route to the Mohawk. As between these two, I should incline to favor your project, because—

1. It would have nearly 200 ft. less lockage.

2. It would bring into the navigation the "finger" lakes in the interior of the State.

3. It would have several millions more tonnage. These lakes would bring it within striking distance of the Clearfield bituminous and the anthracite coal beds in the Susquehanna Valley.

4. Half of the Lake Erie water put on the Rome summit would enter the Hudson River, where more water is a necessity.

Public discussion by competent persons will bring out favorable facts not generally known. Elnathan Sweet, E. P. North, William Pierson Judson and doubtless others, can add much to the public knowledge of the question.

Yours truly, Chauncey N. Dutton.

11 Broadway, New York city, Jan. 22, 1898.

(Space permits comment on only one or two points raised in the above letter. The proposition to suspend work on outstanding Erie Canal contracts, which was made by the State Controller, Mr. Roberts, appeared to us eminently wise. The contractors would, of course, be entitled to reimbursement for the expenditures already made and probably for loss of profits as well. There is such a slim prospect that additional funds will be forthcoming from the State to complete the work, and so little benefit will be derived from the expenditure until it is completed, that it seemed only common sense to save so much of the $9,000,000 appropriation already made as was possible. However, the question is already settled by Mr. Aldrich's refusal to suspend the contracts and Controller Roberts' announcement that the rest of the bonds will be sold next month. The former is doubtless acting for what he conceives to be the best interests of the State, and we believe Controller Roberts' proposition was made with equally good intentions.

As to our statement that the additional $7,000,000 now asked for is pretty sure to be supplemented by other heavy calls upon the taxpayers of the State, we do not pretend to have made a detailed investigation of the subject, but such improvements as electric towing certainly are not provided for by the present improvement scheme. Turning to the report of the State Engineer for 1896, we find a large part of it taken up with plans for a great water storage dam on the Genesee River, estimated to cost 1½ to 2½ millions in round figures. This is declared to be necessary to furnish a sufficient water supply for the improved Erie canal. There are also investigations in connection with storage reservoirs on the upper Hudson, and it is stated that "nearly all the reservoirs which feed the Middle Division of the canals have had practically no repairs for many years." It is also our understanding that the $16,000,000 which is now asked for to complete the 9-ft. deepening, represents the very least for which the work can be done, and does not provide for the rebuilding of a large number of bridges, dams, aqueducts and other structures along the line of the canal, which should be entirely reconstructed and must be before many years. Doubtless if a thorough investigation of the canal expenditures is made, as is now proposed, the public will have some further estimates as to what sum is necessary not only to complete the canal improvements now under way, but to put the canals in such condition that no further outlays for other than ordinary repairs will be needed for at least ten years to come.—Ed.)

Notes and Queries.

In our issue of Jan. 13, p. 31, an error occurred in Table II. accompanying the article by Mr. S. Bent Russell on "Testing Materials by Impact." In the last five lines of the table the decimal point was moved three places to the left. Thus 1.625 should have been 1,625, etc.

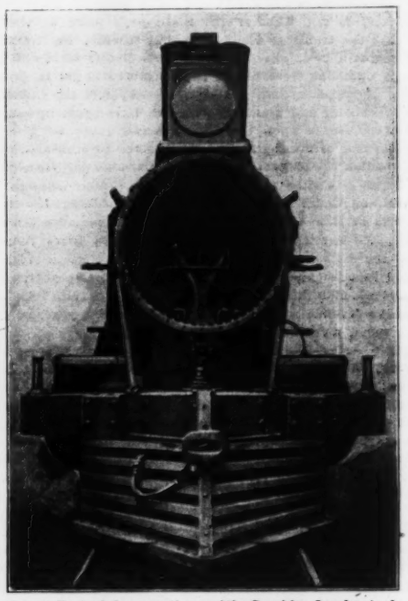
C. G. writes: "If you have the information, kindly give me the spacing of bents in the wooden trestle of the Atlantic Highlands, Red Bank & Long Branch Electric R. R., illustrated in your issue of Jan. 13." On the curved approach the distance between bents is 16 ft. c. to c., while on the tangent the distance is 16½ ft. c. to c., in both cases measured horizontally along the center line of the trestle, i. e., midway between the two tracks.

H. C. S. asks whether any 120-lb. rails are in use in the United States, and if so where they are rolled. We do not now recall any rails heavier than 100 lbs. in use, either in this country or elsewhere. Mr. C. P. Sandberg, of London, has recently designed a rail section heavier than 100 lbs., but we believe it has not yet been rolled. If any of our readers can furnish further information we shall be glad to hear from them.

LOCOMOTIVES WITH DOUBLE SMOKE STACK; TOLEDO, PEORIA & WESTERN RY.

In our issue of Jan. 6 we illustrated the front end arrangement of an English four-cylinder compound locomotive having two exhaust pipes and two smokestacks, connecting with two separate compartments of the smokebox. It will probably surprise many of our readers to learn that double smokestacks and nozzles are in regular use in this country, but this arrangement is the special feature of the Warren draft equalizer which is in use on several engines of the Toledo, Peoria & Western Ry., and also on the St. Louis, Chicago & St. Paul Ry.

The cut shows this device as applied to a Rogers consolidation locomotive of the T., P. & W. Ry., from which it will be seen that the smokestacks are placed side by side, instead of one in front of the other, as in the English engine referred to. The two exhaust pipes meet at the base of the Y-pipe, and each discharge of steam from each cylinder exhausts through both smokestacks. The nozzles are flush with the horizontal sheet of netting, the vertical portion of which is seen in the upper part of the smokebox. It is claimed that this arrangement gives a more uniform draft through all the tubes than when a single central



Front End of Locomotive with Double Smokestack and Exhaust Nozzle. Toledo, Peoria & Western Ry.

exhaust nozzle is used, the latter arrangement tending to produce the heaviest draft through the middle tubes. It is also claimed that this will give a greater steaming capacity and a reduction in fuel consumption.

The following table shows the results of comparative trials made in August, 1896. On the Western Division the comparison is between two passenger engines with cylinders 16 × 24 ins., each of which made two round trips between Peoria and Keokuk, 113 miles (or 452 miles in all), with 25 station stops per hundred miles. On the Eastern Division the comparison is between five engines of the same class, three having the double smokestacks. Each engine made two round trips between Peoria and Effner, 111 miles (or 444 miles in all), with 19 station stops per hundred miles. The speeds were calculated from start to stop, between stations, and all the engines were in equal running condition:

Table Showing Comparative Results of Locomotives with Single and Double Smokestacks; T., P. & W. Ry.

	Average— Single stack.	Double stack.	In favor of double stack, %.
Western Division.			
Ton-miles per train per trip	16,950	16,950	0
Speed, miles per hour	32.60	33.50	3
Water evap. per lb. of coal, lbs.	5.00	5.50	10
Miles run per ton of coal	50.60	55.80	11
Coal per ton per mile, lbs.	.259	.239	8
Eastern Division.			
Ton-miles per train per trip	16,420	16,474	0.33
Speed, miles per hour	40.60	40.80	0.5
Water evap. per lb. of coal, lbs.	4.60	5.00	9
Miles run per ton of coal	35.80	39.20	11
Coal per ton per mile, lbs.	.372	.345	8

This device is the invention of Mr. W. B. Warren, General Foreman of the Toledo, Peoria & Western Ry., at Peoria, Ill., to whom we are indebted for photographs and information.

THE FOUNDATIONS OF THE NEW POST-OFFICE AND GOVERNMENT BUILDING AT CHICAGO.

The question of the proper design of foundations for large buildings in Chicago has always been an interesting one, owing to the existence of a deep bed of clay overlying the hard material. Under these conditions two different types of foundations have been developed: First, the deep foundation, which is carried down by piles or masonry piers through the clay to the hard stratum underlying it; second, the spread or surface foundation, in which the weight is distributed over a broad flat area (usually by a platform of I-beams and concrete), the foundations being so designed as to give a light and safe load per sq. ft. of area covered. The first type is adapted to and required for heavy masonry structures, while the second type is adapted to the modern type of office building construction, the steel skeleton and light curtain walls of which keep the weight down to very moderate limits.

One of the most interesting pieces of foundation work now in progress in Chicago is that for the new post-office and government building, which will be a massive and heavy masonry structure, requiring foundations carried down through the clay to the hard material. This work is described in the present article, which has been prepared after an examination of the work, and from information furnished by the engineer, the architects and the contractors.

The old post-office at Chicago was built upon a concrete foundation, the continuous settling of which, into the clay stratum upon which it rested, caused considerable damage to the building, and led eventually to the building being torn down in 1896 to make room for a new structure on the same site, to be used for post-office, custom house and the federal courts. The architect for this new building is Mr. Henry Ives Cobb, of Chicago, and Gen. Wm. Sooy Smith is the engineer in charge of the foundations. The site is the entire block bounded by Clark, Dearborn and Adams Sts., and Jackson Boulevard, with a length of about 397 ft. on the first two streets and 322 ft. on the other two. The ground is blue clay of varying consistency, overlaid by 8 to 10 ft. of filling, and extending down to a bed of hard pan which lies at an average depth of about 72 ft. below the street grade. Borings have shown a depth of 100 ft. to bed rock. Fig. 1 gives a plan of the site, and sections of four borings made at the corners. These borings were made in May, 1896, under the direction of Gen. Sooy Smith, and were furnished to the contractors "as general and not specific information, the contractor assuming all chances as to the formation of the soil."

In view of the failure of the old concrete foundations it was predicted that the pneumatic caisson system would be adopted to carry new concrete and masonry foundations down to a hard stratum, but after careful investigation Gen. Sooy Smith decided in favor of pile foundations driven down to this stratum, the wet clay protecting the piles from rot or decay. It was expected that a considerable amount of water would be met with, but this was not found to be the case. The contract for the foundations was let to the McArthur Bros. Co., of Chicago, for $208,453.

The piles are arranged in rows for the outer walls and in clusters of various sizes for independent foundations distributed over the site. They are spaced 3 ft. to 3 ft. 6 ins. c. to c. About 5,000 piles are required, all being of Norway pine, 50 ft. long, with square ends, and all are driven to firm resistance. The bottom of the trench is about 28 ft. below the street grade, and adding 48 ft. for the pile, after the head has been cut off, gives about 76 ft. to the foot of the pile. Upon the piles are white oak caps 14 × 14 ins., and upon these caps is a close flooring of white oak timbers, 12 × 12 ins. A bed of concrete, 3 ft. thick, is laid upon this platform, and upon this the masonry pier is built up to the required grade, which is 9 ft. 6 ins. below the sidewalk level. Fig. 2 shows the character of these foundations. The basement floor will be about 9 ft. below the sidewalk, and a masonry curb wall or retaining wall will be built around the site, on the line of the street curb. This also is shown in Fig. 2. The stone for the piers and the curb walls is Joliet limestone, laid in courses of about 12 ins. in thickness. The cement used for

the concrete and mortar is Alpha Portland cement, supplied by the Dickinson Cement Co., of Chicago. Part of the clay excavated from the foundations is dumped back around the completed work as back-filling, and the remainder is hauled away.

The filling and the top layer of clay were first excavated, the material being broken up by heavy 14-in. breaking plows, hauled by two, four or even six horses. One man held the lines, another held the plow handles, and a third pressed down on the plow beam to hold the share down to its work. The stuff was shoveled into four-wheel wagons having removable sides and drop bottoms. Each wagon was hauled by two horses, and extra teams were used to help pull the wagons up the inclines as the excavation became deeper. At first the excavation was done by through cuts, the wagons being driven in at one end, loaded with material excavated at each side of the roadway, and hauled out at the other end. End pits were also excavated, wide enough for the wagons to turn round at the face of the work. Owing to the slippery and muddy condition of the excavations, plank roads were laid for the wagons, these roads being shifted sideways into the excavated trench and the old roadbed then excavated, as the work progressed. An inclined plane was built on the Dearborn St. side and the wagons were assisted up this by a hoisting engine and wire cable. When the stiff, wet clay was reached the shovelers were furnished with pails of water in which to dip the shovels after each cut, and about half the men were equipped with forks to load onto wagons the slabs of clay loosened by the shovels, it being too hard work to remove the heavy mass which stuck to the shovels.

When the stripping and surface excavation had been completed trenches and pits were excavated for the rows and clusters of piles. The pile driving is done by Vulcan-Nasmyth steam pile hammers, made by the Vulcan Iron Works, of Chicago (Eng. News, July 16, 1896). The hammer head itself weighs 4,400 lbs., while the total weight of hammer, cylinder, pile cap, etc., resting on the pile head is 9,200 lbs. The machine strikes about 60 blows per minute. For the first 25 ft. the piles go down quite easily, but the last 12 or 15 ft. is very hard driving, the penetration during the last 200 blows being less than ½-in. per blow. As the banks of the trenches were too soft to support the pile driver, the machine was supported by loose caps on the piles and as it advanced it drove the piles to within about 15 ft. of the finished grade. When it reached the end of the trench it was then worked backward, driving the piles down to the finished grade by means of a follower, consisting of a 15-ft. length of piling shod with iron at each end. By this means the pile hammer was not lowered beyond the leads of the pile driver frame. Near the center of the site a mound of clay was left unexcavated, and in driving the piles in the trench along one side of this, it was found that by the pressure produced by the displacement of the clay the mound was moved over bodily about 4½ ins. The pile driving in the trench on the opposite side brought the mound back to within ½-in. of its original position. An ordinary gravity pile driver, with a 1,500-lb. hammer, was first used to drive the sheet piling for supporting the sides of the trenches, but subsequently the Vulcan-Nasmyth steam hammer was used to better advantage.

For handling the concrete and stone, four derricks with long trussed booms were erected in approximately the positions shown by dotted squares in the plan in Fig. 1. The masts are 16 × 16 ins. in section, 80 ft. high, and the booms are 14 × 14 ins. section and 70 ft. long, trussed by four rods. The hoisting capacity of each derrick is 8 tons, and each is operated by a 20 HP. hoisting engine made by the American Hoist & Derrick Co., of St. Paul, Minn. The engine handles the load, raises or lowers the boom, and swings the mast and boom by means of a wire rope passed round a bull wheel at the foot of the mast. Four smaller derricks are also used to hoist tubs of clay from the pits and dump the clay around completed masonry piers as back filling.

The following is an abstract from the specifications for the foundation work:

Piles.—All piles are to be of the same kind of wood, but may be of any one of the following: Hard, yellow, first-growth, untapped, Southern pine, or oak, or Norway pine. They must be not less than 10 ins. diameter at the small end and not less than 16 ins. or more than

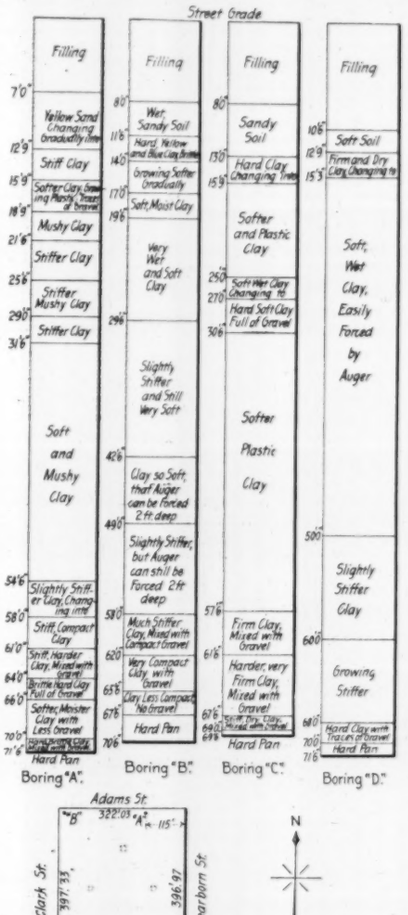


Fig. 1.—Section of Borings on Site of Chicago Post Office.

23 ins. at the butt. Each pile must be sound throughout, of natural growth, reasonably straight and true along its entire length; properly trimmed, and the small ends sawed off to a plane normal to the axis of the pile.

The piles are to be driven with a steam hammer, the machine to be placed in the trench or on a level with the general excavation, as the contractor may choose. Should the latter method be adopted, the guides must be lengthened to reach within 4 ft. of the bottom of trench or pit, and if a follower is used the head of the pile shall be properly protected from injury by a suitable iron ring. The heads of all piles must be sawed off accurately on a horizontal plane true to the required level. All piles must be driven until they reach and fetch up hard on the very hardpan underlying the clay, and the pile shall not sink more than ½-in. for the last six blows of a 2,000-lb. steam hammer with full force. All piles must be of sufficient length to fulfil the above conditions whatever the soil may be. The average depth of hardpan is assumed to be 72 ft. below the inside sidewalk grade and is to be taken as a basis of length of pile. Should any portion of the ground require piles exceeding 48 ft. in length when cut off to the required level figured on the drawings, the contractor is to receive an additional amount per foot.

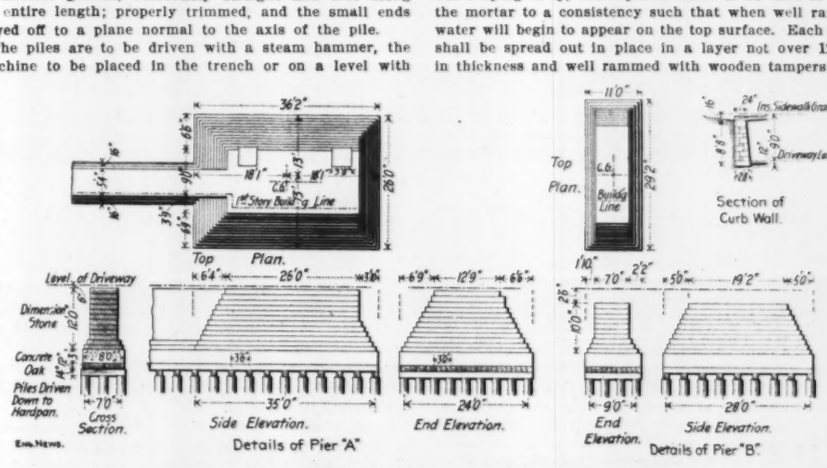


FIG. 2.—TYPE OF FOUNDATIONS FOR CHICAGO POST OFFICE.

Platform.—After the heads of the piles have been sawed off, the earth around them is to be thoroughly tamped, well rammed and smoothed off to the level even with the top of the piles. The piles are then to be capped by white oak caps, 14 × 14 ins., of lengths shown on the drawings. The caps shall be fastened to the pile heads by means of 1-in. wrought-iron drift bolts 24 ins. long, one in each end of each cap timber. All joints and ends of all timbers are to be sawed square, and joints properly broken so that no two, as far as practicable, will come on the same line, and all butt joints are to come directly over center of pile heads or cross caps. The caps are to project over the outer edge of the top of the outside piles. On top of these cap timbers a platform will be laid consisting of white oak timbers 12 × 12 ins., closely laid in random lengths, no timber being less than 12 ft. long. The outside timbers of each platform to be bolted to each cap timber on which they rest with one 1-in. wrought-iron drift bolt 20 ins. long.

Cement.—All cement is to be Portland cement, equal to the best brands of American Portland cement. Briquettes made of 1 part cement to 2 parts sand (by measure), after 24 hours in air and 6 days in water, must show 250 lbs. tensile strength. Where sand is used in testing cement it is to be the same sand as used on the work. The cement must be sound, free from excess of free lime, sulphur, or other hurtful constituents. Pats of neat cement after 30 days in water, must be free from blow holes or expansion wastes. Long-time tests of neat cement must show continued increase in tensile strength, and any falling off inside of one year, as shown by examination of same cement as previously used on other work, will be taken as sufficient cause to reject any cement without regard to initial strength. The cement shall be fine ground, so that not more than 6% shall be held on a No. 100 sieve.

Stone.—The stone must be of the best quality Illinois limestone, or other stone which in the opinion of the architect is of equally good quality and in every way suitable for the purpose for which it is to be used. All broken stone for concrete to be clean and hard stone, free from pyrites (sulphate of iron), and broken so as to pass all ways through a 2½-in. ring.

Mortar.—One barrel (380 lbs. net) of cement to be mixed dry with two barrels (not over 8 cu. ft.) of sand, and sufficient water added, after mixing dry, to give it the consistency of plastic mortar.

Concrete.—One barrel (380 lbs. net) of cement thoroughly mixed dry with two barrels (or not more than 8 cu. ft.) of sand, mixed with five barrels of broken stone that has first been thoroughly wet and drained and then spread out on a tight platform to a uniform depth. The dry mixture of sand and cement is then to be spread uniformly over the pile of stone. The whole pile to be then turned over at least three times with a shovel, without heaping it up, the required water to be used to bring the mortar to a consistency such that when well rammed water will begin to appear on the top surface. Each batch shall be spread out in place in a layer not over 12 ins. in thickness and well rammed with wooden tampers until free mortar appears on surface. No part of any batch shall be used if the cement in it has been wetted for half an hour prior to being put in place in the work. No concrete shall be laid on any layer of concrete that is dirty or that has set. Where previous layers have set, as over night, the top surface must be cleaned and plastered with fresh mortar, and the additional concrete laid on this mortar bed while fresh and before it sets.

The entire surface of all timber platforms is to have

a bed of concrete, 3 ft. thick, and the contractor is to securely construct 2-in. plank curbs, 3 ft. in height, and of the neat area of all said platforms, and securely brace the same to sustain the concrete until it has set, when such curbs may be removed. The space is then to be thoroughly filled in, puddled and rammed with clean earth filling level with the bed of concrete.

Masonry.—Build all dimension stone walls and footings in level courses 12 ins. in height, including joint. No stone to be less than 2 ft. wide or contain less than 10 sq. ft., unless the area of piers have a less area, in which case each course shall be the full area of said piers. All beds are to be out of wind, and scabbled off so that no depressions shall exceed ½-in. below the mean level; and all stone to be set upon its natural bed by derricks, and so shaped and set to break joints and form a thorough bond. All butt joints to be square and plumb, and not exceed an inch in width. All courses to be thoroughly bedded in cement mortar and all butt joints thoroughly filled and grouted with said mortar. The top beds of all top courses of stone in all piers and walls after being set are to be dressed off true and even to the various levels figured on the drawings.

The stone curb walls are to be laid to a line both sides and in level courses, about 2 ft. in length, with large flat stone with level beds, thoroughly well bonded and bedded in cement mortar, with all interstices well filled with sand mortar and stone spalls. There shall be at least one good-sized bond stone to each 12 sq. ft. of wall surface extending through said walls; all joints on both sides of walls are to be raked out and carefully pointed, and the street side of all curb walls are to be plastered 1 in. thick with cement mortar.

TESTS OF SPECIAL QUALITY CHILLED IRON CAR WHEELS AT BUFFALO, N. Y.

A series of tests of chilled cast-iron car wheels of special quality designed for use under locomotives, passenger cars, and 100,000-lb. capacity freight cars, was conducted under the auspices of the Central Railway Club on Jan. 21, at the shops of the New York Car Wheel Works, and the P. H. Griffin Machine Works, of Buffalo, N. Y. The committee appointed by the Central Railway Club to supervise the tests consisted of Mr. A. C. Robson, Division Master Car Builder, Lake Shore & Michigan Southern Ry.; Mr. J. A. Bradley, General Foreman, Car Department, New York, Chicago & St. Louis Ry.; and Mr. Robert Potts, Division Master Car Builder, Michigan Central Ry. A party of about 100 railway men, engineers and guests witnessed the tests.

The primary object of this series of tests was to demonstrate the comparative value of steel tired wheels, and special quality chilled iron wheels for high grade service. For this reason the very severe tests required by the leading European railways for steel tired wheels were adopted, and were supplemented with a number of standard and special tests required on various American railways. In 1895 the same firms conducted a similar but not so extended a series of tests, the results of which (Eng. News, Nov. 14, 1895), showed the ability of the wheels tested to withstand over double the required number of blows demanded by the different European railway specifications. Still better results were obtained in the present series of tests, as will be seen upon consulting the figures given further on. The list of tests made on Jan. 21, and the character of each are given in the following abstract from the preliminary announcement:

Tests Required Under the Specifications of the Leading European Railways for Steel Wheels.

Australian State Railway Test.—Wheels placed upright on heavy iron and stone foundations. Weight of 475 lbs. dropped from varying heights, commencing at 1 m. (3.28 ft.), and increasing by half meters to 6 m. (19.68 ft.). Wheel must stand eight blows in all. Test will be continued until wheel is broken.

German State Railway Test.—Wheel placed horizontally on heavy iron and stone foundation. Tapering steel wedge placed in bore. Weight of 475 lbs. dropped from varying heights, commencing at 1½ m. (4.92 ft.), and increasing by half meters to 4 m. (13.12 ft.). Wheel must stand six blows in succession without bursting. Test to be continued until wheel is broken.

French State Railway Test.—Wheel placed upright on heavy iron and stone foundation. Weight of 2,200 lbs. dropped from a height of 4½ m. (14.76 ft.) Wheel must stand three blows without breaking. Test to be continued until wheel is broken.

Test Required by American Railways for Cast Iron Wheels.

Master Car Builders' Test.—Wheel placed horizontally on heavy iron and stone foundation. Weight of 140 lbs. dropped from a height of 12 ft. on hub. Required to stand five blows.* Test to be continued until wheel is broken.

Pennsylvania R. R. Thermal Test.—Wheel laid flange down in the sand and a channel-way 1½ ins. wide and 4 ins. deep molded with green sand around the wheel. This channel-way will then be filled with molten cast iron; two minutes later an examination of the plates will be made. Wheel to be accepted, must not be broken in pieces, and the cracks in the plate, if any, must not extend through the tread.

Bursting Test.—An axle having wheel seat turned with offsets increasing by 1-64-in., will be forced into the bore of a wheel by the hydraulic press. There will be five offsets which will increase the diameter of the wheel seat by 5-64-in. over diameter of wheel bore, and pressure will be recorded for each offset. Test will be continued until wheel breaks.

*Pennsylvania R. R. requires twelve blows. Lehigh Valley R. R. requires nine blows.

Tests on Axles of Standard and Special Qualities.

Test No. 1.—The end of a cold rolled axle will be supported, and pressure brought to bear at the center to bend it out of line and it will then be allowed to spring back. The pressure for each deflection and the permanent set, if any, will be recorded.

Test No. 2.—Same as test No. 1 on ordinary steel axle of the same diameter, and Master Car Builders' specification.

Test No. 3.—A 4-in. cold rolled axle, 6 ft. 5 ins. in length, of the special quality furnished for electric service, will be bent cold in the hydraulic press until the ends are brought together. An examination will then be made to see if any cracks appear at the bend.

The following results of the tests are compiled from the note books of the committee in charge of the testing, and from notes taken by a member of the staff of this journal, who was present at the tests.

Austrian State Railway Test.—The test was made on a wheel 36 ins. in diameter, weighing 860 lbs., made according to the specifications of the Austrian State Railways. This test requires the wheel to withstand eight blows before breaking in two, and it resulted as follows:

First to 9th blows, no effect; at 9th blow a small crack appeared in the tread 4 ins. long, which gradually increased to 12 ins. in length at the 12th blow; 13th to 18th blows, no change; 18th to 21st blows, crack gradually extended to the plates; 21st blow, crack extending through both plates and around the hub to the tread on the opposite side; 22d blow, wheel broke into two pieces. The chill was ⅝-in. and ¾-in.

Austrian-Hungarian Test.—The test was made on a 33-in., 650-lb. wheel made according to the Pittsburg, Bessemer & Lake Erie Ry. specifications for 100,000-lb. cars. The requirements of this test are the same as for the preceding Austrian State Railways test. The results were as follows:

First to 7th blows, no effect; 7th to 15th blows, small cracks developing and extending through tread and plates; 16th blow, wheel broken into two pieces. The chill was 9-16-in. and 10-16-in.

German State Railway Test.—The test was made on a 33-in., 650-lb. wheel made according to the specifications of the Master Car Builders' Association. In this test the wheel is required to withstand six blows before breaking in two, and it resulted as follows:

First to 14th blows, no effect; 14th to 16th blows, crack extended throughout hub and plate; 16th blow, wheel broke into two pieces.

French State Railways Test.—The test was made on 33-in., 650-lb. wheel, made according to the Lake Shore & Michigan Southern Ry. specifications for locomotive tenders. This test requires the wheel to withstand three blows, and it resulted as follows:

First to 6th blows, no effect; 6th blow, crack 8 ins. long in throat, parallel to flange and crack through rim of wheel at bottom to the single plate; wheel unbroken and test discontinued.

Belgian State Railways Test.—The test was made on a 39-in., 900-lb. wheel, made according to the specifications of the Grand Central Railway of Belgium. The requirements of this test are the same as for the preceding French Railways test. The test resulted as follows:

First to 7th blows, no effect; 8th blow, wheel broken into two pieces. The chill was 11-16-in. and ¾-in.

Master Car Builders' Test.—The test was made on a 33-in., 600-lb. wheel, made according to the Master Car Builders' specifications. This test requires the wheel to withstand five blows, and it resulted as follows:

First to 26th blows, no effect; 27th blow, small crack in bottom plate; 28th blow, crack extended to [illegible] 28th to 47th blows, no change; 48th blow, crack through plunge; 49th to 85th blows, cracks gradually extending; 86th blow, wheel broken into two pieces. The chill was 9-16-in. and ⅝-in.

Pennsylvania R. R. Thermal Test.—The test was made on a 33-in., 600-lb. wheel, made according to the Pennsylvania R. R. specifications. The test was made as follows:

The molten band 4 ins. deep and 1½ ins. thick was cast in 14 seconds and allowed to remain two minutes. The wheel stood the test without failure of any kind.

Bursting Test.—The test was made on a [illegible]-in., 650-lb. wheel, made according to the specifications of the Pittsburg, Bessemer & Lake Erie [illegible] and resulted as follows:

An axle, having five offsets, and the largest diameter of which was 5-64-in. greater than the bore of the wheel, was pressed into the bore of the wheel to the maximum pressure of a 100-ton hydraulic press without any apparent effect on the wheel.

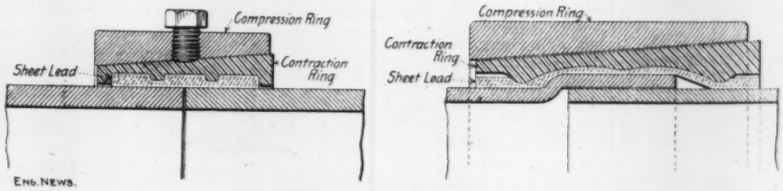
The car wheel tests were followed by a series of tests on cold rolled steel axles, and steel axles made according to the specifications of the Master Car Builders' Association. The first test was a comparative test between a 3⅜-in. cold rolled steel axle and a M. C. B. steel axle 4½ ins. in diameter at the center. The test was a bending test, and was made by placing the axles on supports spaced 6 ft. 6 ins. apart, and applying the load at the center by means of a screw jack. The axles were deflected ¼-in., ½-in., ¾-in. and 1-in., in succession, the load being removed after each deflection and a measurement taken to determine the amount of permanent set. The results were as follows:

Deflection, ins.	Permanent set, ins.—Cold rolled.	M. C. B.
¼	none.	none.
½	"	1-16
¾	"	⅛
1	⅛	⅝

Following this test a cold rolled steel axle was bent out of line 1 in. and the load removed. The permanent set was 1-16-in. A cold rolled steel axle was then bent in a hydraulic press until the ends met, and showed no defects at the point of flexure.

AN ENGLISH RING JOINT FOR METAL PIPES.

A new joint applicable to a variety of kinds of pipe has been invented by Mr. D. J. Russell Duncan, Assoc. M. Inst. C. E., M. Inst. M. E., of 28 Victoria St., Westminster, London. Lead is used for making the joint tight, being forced to and held in place by two wedge-shaped rings, the inner one originally being open at one point to admit of compression, and the outer one being continuous. Two styles of joints are shown by the accompanying illustrations. Fig. 1 is an ordinary butt joint, and Fig. 2 a hub and socket joint. Almost any other form of joint desired may be made by this system, simply by varying the form of the inner or contraction ring. Joints may be made for pipe of any size and to withstand any desired pressure. No bolts or nuts are required.



RING JOINT FOR METAL PIPES.
Invented by D. J. Russell Duncan, M. Inst. C. E.

Fig. 1.—Butt Joint.

Fig. 2.—Hub and Socket Joint.

In making the joint two pipes are brought together, and a strip of sheet lead, ⅛-in. or more in thickness, is wrapped around them, with overlapping edges. The lead is drawn tight and compressed by forcing together the two rings shown in Figs. 1 and 2. The inner ring is sheared from a rolled steel bar of the desired section, and bent to the proper diameter, but not joined at the ends until compressed by the outer ring. This gives clearance space between the pipe or lead and the ring, prior to completing the joint. The outer ring may be made of a steel bar, welded, or of cast-iron. The inventor states that this ring may be forced into place by either screw or hydraulic jacks, which are especially designed for the pur-

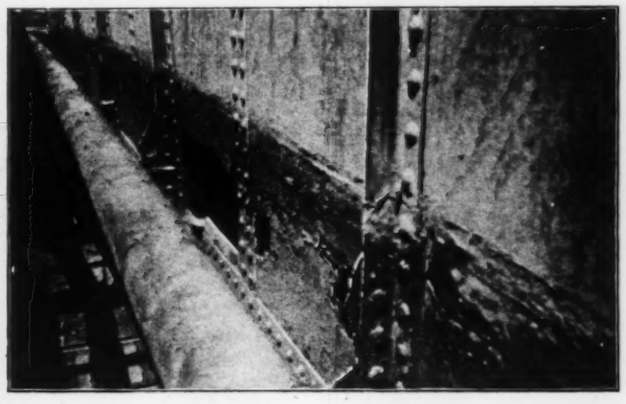
pose. These jacks are attached to a frame suspended by a single hook and chain from a derrick, the jacks fitting the pipe at equi-distant points on its circumference.

The parts of the joint are slipped loosely over the pipe before it is lowered into the trench, and the pipe is butted and bedded in advance of the jointers. Mr. Duncan states that a joint can be made in a very few minutes, no calking being required under ordinary pressures, and no lead being wasted; also that this form of joint requires only about 65% as much lead as the ordinary joint and can be made in less time and with less labor. An important advantage claimed for the joint is the facility with which it can be made in wet trenches. Another claim for it is the ease with which a joint can be disconnected, a few blows of the hammer driving back the compression ring, after which the inner ring can be sprung open with a wedge and removed and the lead is then stripped off without loss.

By grooving the ends of the pipe, lock joints can be formed. Expansion joints can also be made by increasing the width of the lead packing and of the rings.

The rings for the joints can be rolled as cheaply as other shapes and are light. They can be shipped easily, and pipe designed to have this form of joint permit of an economy of space in shipping by sea over some other forms, besides which there are no flanges to break off. In flanged joints, too, the packing used is sometimes perishable.

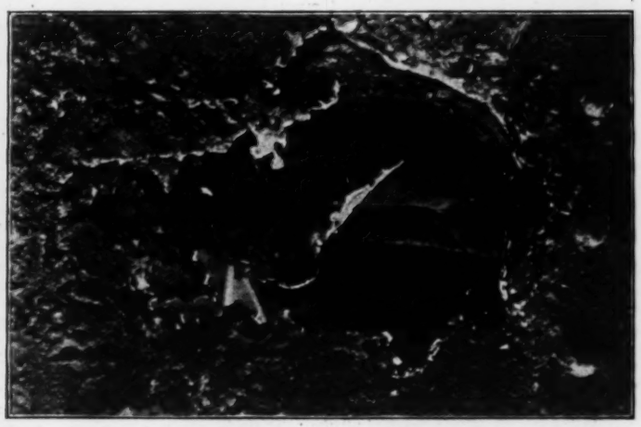
View of East Girder.



View of West Girder.

THE CORROSION OF A PLATE GIRDER BRIDGE BY LOCOMOTIVE GASES.
VIEWS OF MAIN GIRDERS OF WASHINGTON ST. BRIDGE OVER BOSTON & ALBANY R.R., BOSTON, MASS.

West Girder in Process of Removal.



Hole in the Web of West Girder.

PAINTS FOR THE PROTECTION OF IRON WORK.†

By A. H. Sabin,* Assoc. M. Am. Soc. C. E.

The great enemy of all iron and steel work is rust. Iron does not occur in the metallic state in nature, but the web were ¼-in. thick. Originally the roadway was carried on floor beams depending on these girders, but some years ago, on account of the weakened state of the latter, the floor beams were replaced by girders, so that these old girders only carried the sidewalk; or rather, each carried one-half of one walk, the outer half of each walk having always been carried by a narrow girder put up in 1871, which did not rust much because, being at the extreme outer sides of the structure, the smoke and steam readily passed away from it into the unconfined air. The whole bridge was regularly and frequently painted, and the paint did protect these outer girders; but under the middle of the bridge the conditions were so severe that the paint was rapidly destroyed, and in consequence the progress of corrosion was nearly continuous.

It will be obvious to any one who looks at these pictures that unprotected iron or steel is very far from being a permanent substance, and also that if it is possible to protect it by painting, it is worth taking pains to have it well done. This is especially true of buildings which depend on a steel frame for strength and rigidity, because the metal work cannot be made accessible either for inspection or repainting and all that can be done is to make a good job in the beginning. As a matter of fact, these structures get on the average about the poorest class of work in this line.

The most common specifications say that the metal surfaces should be cleaned so as to be free of dirt and scale, and sometimes it is added that this shall be done by steel wire brushes, with scraping where necessary. There is no doubt in my mind that the right way to prepare a steel or iron surface for painting is to clean it so that the gray color of the metallic iron will be everywhere seen. This may be done in some cases by scraping, in some by pickling, in others by the sand blast; but in all the cost will be considerably more than is now commonly spent, because more work is done, and a better result achieved. When the metal surface has been cleaned, there are two ways for beginning the work; one is to have a shop coat of boiled linseed oil, and the other a shop coat of some paint specified by the engineer. The advantage of the shop coat of oil is that it permits more rapid inspection, and, as few engineers have inspectors in the contractors' shops, it provides for the painting being done under inspection; and as the oil is supposed to protect the metal from rust only, until it gets on the ground, and does not take the place of a coat of paint, it is just so much more protection. The disadvantage is that the contractor may use some other oil than linseed, and thus apply a first coat to the surface which will have a deleterious effect on the paint which is afterward applied. This is not only a possibility, but a very common practice. I happen to know of one manufacturer of a substitute for linseed oil who has more than one hundred customers among the iron contractors of New York city; and while I have seen a very large amount of architectural steel and iron work in the last few years in and about New York city, I have never yet seen any with a shop coat of genuine linseed oil, according to my judgment. The use of mineral oil, which is common in some cases, is, in my opinion, to be strongly condemned; it is injurious to the paint which is afterward applied, and it gives the unscrupulous contractor a small money advantage over his more honest competitors. There is no difficulty in getting pure boiled linseed oil from reputable makers; it is best to buy it directly from the crushers. It will dry in 24 to 36 hours, but does not make a hard film for some time; in fact, it is always rather soft and tough, but not greasy. The advantage of using a shop coat of paint is that the sooner the paint is applied after the surface is cleaned the better it will stick; the disadvantage is that such painting is rarely done under inspection, and as the contractor is always in a hurry to get the work out of the shop, he does not like to wait for the paint to dry, and very often thins it with turpen-

*Chemist, Edward Smith & Co., 45 Broadway, New York city.

†Condensed from a lecture delivered before the students of the Rensselaer Polytechnic Institute and published in the "Polytechnic."

tine or benzine, which makes the painting much easier and makes it dry very rapidly, while, at the same time, it saves him money both in material and labor.

Contract work in painting is almost always unsatisfactory, and calls for the most thorough and persistent inspection. In order to do the work rapidly the painter wishes to thin his paint, usually with benzine. To get the inspector to consent to this he makes a demonstration that the paint is too thick, by using, in the first place, a cheap brush, with the bristles tied around the end of a stick, thus making a hollow brush, having comparatively little capacity, instead of a better brush, which should be practically a solid mass of bristles, and which will hold a large amount of paint; this cheap brush (which indeed he intends to use on the whole job) he dips about an inch in the paint and then rubs it over the iron. As there is not enough oil present to lubricate the passing of the brush over the surface, what little there is serves as an adhesive to make the bristles stick to the iron, and the brush "pulls." This is supposed to show that the paint is too thick and must be made more like whitewash by the liberal addition of benzine and "dryer." What the inspector ought to do in this case is to dip the brush deep in the paint, so as to fill it, then rapidly paint the surface, stopping as soon as the paint begins to be exhausted and dipping it again. Before condemning the paint he should further try it with a first-class brush; and if the weather is at all cold the paint should be warmed by putting the tin pail which contains it in a bucket or tub of hot water. By using this latter device it is within my knowledge that extensive jobs of painting have been done by the Calumet & Hecla Copper Co., the Northern Pacific R. R. Co., and many others, when the temperature was below 50° F., sometimes as low as 40° F., and using one of the thickest and most sticky paints on the market.

Paint should not be put on so as to cover more than 400 sq. ft., one coat, with one gallon of paint, as a rule; and probably no good paint will do it. It might be supposed that by thinning paint with a quarter of benzine would reduce the amount of solid material on a square foot one-fourth; but, in fact, ¾-gallon of paint, which was intended to cover 300 sq. ft., may, by adding to it a quart of benzine or turpentine, be made so light in body that the gallon thus made will cover probably 800 sq. ft.; and if it is a paint containing a well-ground iron oxide or carbon pigment, a coating of this extreme thinness will still be quite opaque, so that the fact that the metal appears to be completely covered is not an indication of sufficient thickness. Some engineers strictly forbid the presence of turpentine or benzine about the premises, disregarding the workman's plea that he must have it to clean his hands, and so on. In no case should any considerable amount be permitted. Specifications should provide that the contractor must exhibit to the engineer bills from the manufacturer's agent of all the paint used, and that it should all be brought on the premises in the manufacturer's sealed packages, and opened in the presence of the inspector, who shall take samples at any time, and the chief engineer may have the same tested at the expense of the contractor.

Most paints consist of pigments composed of some inert substances ground or more commonly mixed in linseed oil; and as one effect of nearly all pigments is to retard the drying of oil, it is usual to add dryers. In the paint trade a dryer is a mixture of lead and manganese compound dissolved in some medium, sometimes in oil, but oftener in turpentine or benzine, or a mixture of these. These act like the red lead in a storage battery, by taking up oxygen and afterward parting with it, thus serving as carriers of oxygen between the air and the oil. The objection to the use of a dryer is that it may continue to act after the oxidation of the oil has reached its normal, and consequently it is a general maxim that all use of dryers is a source of danger. They should not be allowed to be added to prepared paints, which have already been mixed in the proper proportions by the makers.

Care should be taken that all parts of the work receive a coat of paint; if the shop marks, usually in white lead, are allowed to stand unpainted, the inspector should insist that these should be as small and compact as possible, and that special care should be given to these portions of the surface when the second coat is applied. It is to be noted that there is an apparently unavoidable tendency for the paint to be thin on and along the edges; and the best recent practice is to require, after the first coat has been applied and usually after erection, a striping coat of paint applied along the edges and back an inch or two from the edge; after this has become dry a second full coat of paint is applied; the result is that the equivalent of two full coats is applied over the whole surface. It would be a good plan when this striping coat is put on to touch up the rivets also; paint always tends to draw off from rivets, and they usually are the first spots to show rust; it is desirable to have the paint as full as possible around thin edges. After one coat has been put on the surface is comparatively smooth, and of course it will not take as much paint for a second coat; but as the brush slides easily over this surface, it is easy for the workman to apply an extremely thin second coat, and the inspector should be on guard against this. The labor is the largest element in the cost of painting, and it costs nearly as much to put on a thin coat as a thick one; the point to aim at is the application of as thick a coat as will be uniform and will dry thoroughly. It is idle to expect much protection unless the paint film is of appreciable thickness. Many of our best architects are requiring three coats on all work which is to be inaccessible, such as posts and beams in buildings. On bridge work it is usually regarded as good practice to apply two full coats, besides the striping coat, if any is used, at first, and wait some months before applying a third coat.

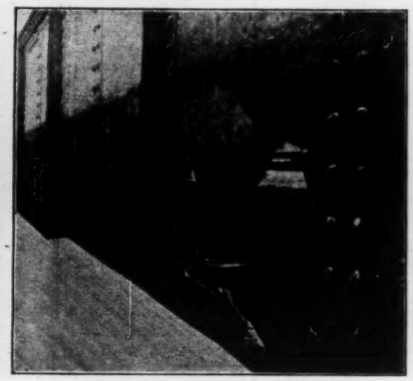
The best time of the year for out-door painting, especially of bridges, is in the hot summer weather. When the weather is hot the paint spreads and flows well and it is practicable to use a paint having heavy body, which is in general the best; the paint dries rapidly, hence we can use a paint with little or no dryer. The work may begin in the morning and continue all day, while in the spring and autumn a bridge, which is usually over a stream, and often in a somewhat secluded place, is likely to be covered with dew until the middle of the forenoon, and the dew begins to deposit on it before it is time to quit work in the afternoon; nothing is much worse than applying paint to a wet or damp surface. A deposit of moisture may occur on iron from another cause; some of the paints in use are thinned with benzine or have as a vehicle a benzine varnish, and some are merely solutions of coal-tar or asphalt in benzine; when these are applied to iron work the rapid evaporation of the solvent cools the metal, and if the atmosphere is nearly saturated with moisture the latter is condensed on the cold surface in advance of the painting. The engineer who is responsible for the work will therefore exercise particular vigilance when using such materials; and he should keep careful memoranda about the weather and all the conditions when the paint was applied, so that in the future some intelligent conclusions in regard to the value of the material used may be reached. A poor paint applied under favorable conditions to a good surface is undoubtedly better than a good paint applied under unfavorable conditions to a poor surface; and often it is difficult to learn what has really taken place after two or three years have elapsed.

There are some particular cases of painting which deserve notice. One is the painting of a tin roof or similar surface. The painters' tradition is that it is impossible to paint a new tin roof; that it must be left until it has become slightly rusty, when the paint will stick to it. There is no doubt that a new tin surface is very difficult to paint. The fault is not, however, in the tin itself, to which paint adheres very well, but in the coating of grease or other material with which new tin is covered. There is some diversity in the methods employed in making tin plate, and consequently it is not all alike, and some brands of new plate hold paint better than others; but as a rule it is covered with grease, either tallow or palm oil, and sometimes with other substances; these act on the paint in a very destructive manner. The obvious remedy is to have the tin roof thoroughly scoured and cleaned before painting, and the whole should be done as soon as possible after the roof is finished. Do not be persuaded by anyone that rust is a good thing to paint over.

Smokestacks are sometimes difficult to paint on account of their high temperature. It is probable that nothing will stand on a surface which has a temperature of 600° F. or over, because, although the pigment may be unaffected, the vehicle, which acts as a cement to hold the pigment together, is gradually decomposed, and in a short time the coating begins to come off. There is, however, a great difference in this regard in different coatings.

In painting water tanks and other hydraulic work care should be taken to select a paint which is acted on as little as possible by water; have the surface as clean as possible, and perfectly dry, and allow the coating plenty of time to dry before filling with water. Remember that paint on the interior surface of a nearly closed tank dries slowly.

View of West Girder at a Floor-Beam Connection.



Corrosion at a Web Splice of West Girder.

A Sample of Corrosion on the East Girder

FALL OF A WATER TOWER AT MARSHALL, MINN.

The water supply of the town of Marshall, Minn., is obtained from artesian wells, and has been pumped to a tank of 60,000 gallons capacity mounted on a steel framed tower 85 ft. high. In "The Manual of American Water-Works" the height is given as 114 ft., but this, we are informed, is the total height to the top of the roof of the tank. The water tower was completed on April 2, 1895, and collapsed Dec. 29, 1897, the

Fig. 1.—Wreck of Steel Water Tower at Marshall, Minn. (Collapsed Dec. 29, 1897.)

wreck being complete, as shown by the accompanying view, Fig. 1, reproduced from a photograph sent us by the U. S. Wind Engine & Pump Co., of Batavia, Ill. According to information received from Mr. H. P. Fulton, architect and builder, of Marshall, the tower was of the four-post type, built by the Carnegie Steel Co., of Pittsburg, according to a general design shown in the company's book. It was erected by Mr. C. T. Sykes, of St. Paul, Minn. The posts were of the section shown, and there were two sets of girders

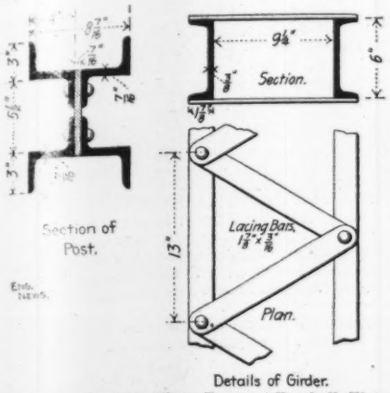


Fig. 2.—Details of the Water Tower at Marshall, Minn.

or horizontal members, dividing the 85-ft. tower into three panels, with diagonal bracing of rods 1-in., ⅞-in. and ¾-in. square, respectively, set up by turnbuckles in the middle. The tank has always leaked, especially during high winds, and the backs of the rivets in the loops were worn bright by the friction due to vibration. The direct cause of the accident is attributed to the freezing of the leaking water upon the tower, it being estimated that there were nearly two tons of ice hanging on one side of the tower at the time of the accident. Mr. Fulton, who has furnished the sketches of the details shown in Fig. 2, thinks that the tower was not strong enough, and that the constant vibration had worn off some of the rivets or bolts. The steel frame which supported the tank was found upside down in the center of the place where the tower had stood.

THE EXTENSION OF THE WATER METER SYSTEM of Washington, D. C., is advocated in a special report made by the District Commissioners to a committee of the Lower House of Congress. The commissioners urge excessive waste, resulting in defective pressure at certain points. They wish to place 3,500 additional meters at once, and extend the system year by year, hoping thus to reduce the consumption to 100 gallons per capita per day.

THE CHICAGO GARBAGE CONTRACTS, recently awarded for five years, as noted in our issue of Dec. 16, 1897, are temporarily held up by a local court decision that the city is exceeding its limit of indebtedness in making a contract for so long a time. In connection with this decision the court makes the astonishing statement that the assessed valuation of the city of Chicago, now $232,000,000, is $30,000,000 less than it was in 1873; notwithstanding the growth of the city in area, population and value of personal property.

THE GARBAGE REDUCTION PLANT AT PITTSBURG may continue in operation, so far as the local court is concerned, but the contractor is ordered to dispose of the garbage as fast as it reaches the works, keeping the digestors tightly closed during the operation and shipping away the products as speedily as possible. The contractor has to pay the costs of the suit. The suit was brought about two years ago by property-owners near the plant. Some months ago an injunction was refused, pending changes in the method of disposal. The suit was recently renewed on allegations that the plant is still a nuisance. The court says in its decision that the city must have some means of disposing of its garbage, and that it is impracticable to locate the works outside the city, since a change to a location anywhere within twenty miles would simply transfer the plant to another center of population. Garbage reduction plants, like manufacturories of any sort, are necessary incidents, the court holds, to the growth of a city, and like manufacturing plants, are injurious to residence districts. The decision may be appealed from.

THE GARBAGE CONTROVERSY AT NEW ORLEANS bids fair to be settled soon by a change from private to public control. A few years ago the city made a 20-year contract for the collection and disposal of its garbage. Trouble arose over the separation of the garbage from the other refuse and the contractor refused to take mixed garbage. The city thereupon declared the contract void and began to make collections, obtaining temporary permission from the U. S. Government to dump the garbage in the Mississippi River. The contract has been in the courts for some time, but recently an agreement was reached under which the city will pay the company $150,000 in settlement of all past claims, and for a part of the plant of the company, including real estate and buildings, but excluding everything pertaining to the Simonin system of garbage reduction, which latter the city does not want. It is expected that the transfer will be made in a few days.

THE NEW JERSEY STATE ROAD COMMISSIONER, Mr. Henry I. Budd, has made his report for the year ending Oct. 31, 1897. He shows that, under the law of 1895, 66½ miles of improved roads have been built in the last year at a cost of $100,000 to the State and $200,000 to the counties and property owners, an average cost of $4,511 per mile. Specifications have been prepared for about 90 miles to be built this year. Since 1895 the total length of roads built under the State law is about 258 miles, upon which the State expended $440,350 and the counties and property owners a little over $1,000,000; the average cost per mile being thus over $6,000. Most of these roads are macadam, though gravel roads are used in South Jersey. Mr. Budd says that the average cost of the modern roads has been reduced fully one-third; roads are now built for from $3,000 to $4,000 per mile where they formerly cost from $6,000 to $9,000.

A FIREPROOF BRIDGE FLOOR is to be laid on the Port Perry bridge over the Monongahela River, now under construction for the Union Railway. This bridge is an unusually heavy steel structure, with one 400 ft. span, two 150 ft. spans and three 180 ft. spans, with steel approaches. It is calculated for a moving load of 5,000 lbs. per lineal foot. As the Carnegie Steel Co. proposes to haul hot metal across it from the Edgar Thomson furnaces to the Homestead Steel Works, the down river track will be protected by a floor of steel buckle plates, carried on steel beams, and supporting a pavement of fire-brick, laid on edge. The upper track, over which the empty metal cars will pass, will be of ordinary construction. The bridge is being built at the Keystone Bridge Works.

FIREPROOF BICYCLE SHEDS are to be built at the State, War and Navy Department buildings in Washington to accommodate the 1,000 or more bicycles used by the clerks and now stored in the corridors of these buildings. The estimated cost of the structure, according to plans submitted to the Secretary of the Treasury, by Chief Engineer G. W. Baird, U. S. N. and Superintendent, of these buildings, is $1,983.

THE COLORS FOR SIGNAL LAMPS have been made the subject of a letter ballot by the Railway Signaling Club, with the following results: 26 for red (danger) and green (clear); 9 for red (danger) and white (clear); 3 for other arrangements. This represents a strong opinion in favor of the elimination of the white light for signals on the part of the men who manufacture and have charge of signal equipment.

LIMITING THE HEIGHT OF BUILDINGS is recommended by Chief Haddock, of the Bureau of Building Inspection of Philadelphia, in his annual report. An act for such prohibition was introduced at the last session of the Pennsylvania Legislature, but failed to pass.

It provided that the height of any building be limited to three times the distance from its base line to the center of the street, and that in no case, even on the widest streets, should a building of a greater height than 150 ft. be erected.

Mr. Haddock expresses the opinion that a bill of this kind should again be introduced, and should become a law, because a just and proper restraint excesses of this kind would encourage a more general development of the city, and if such restraint is proper, the sooner it is begun the better. He also believes that the appreciation of real estate values, consequent upon the erection of tall buildings and their concentration within a small area, will tend to depreciate values of real estate in territory near by, with consequent loss of revenue to the city.

TELEPHONING FROM A SUBMARINE BOAT was successfully performed on Jan. 6 in the Harbor of Baltimore, Md., over a wire connecting the submarine boat "Argonaut" with the office of the Lake Submarine Co., in Baltimore. The line consisted of an Okonite wire wound upon a reel enclosed in a water-tight casing and arranged to play out as the boat advanced. After the boat had settled on the harbor bottom Mr. Simon Lake, its inventor, called up the Central office in Baltimore and later in Washington. The test proved an entire success.

THE EXTRA CONSUMPTION OF ILLUMINATING GAS due to fog is well illustrated by some figures given out by London, England, gas companies. These figures reveal the fact that the excess of gas used due to a fog lasting an entire day, would be sufficient to supply a town of from 10,000 to 20,000 inhabitants for a year. The total consumption on such a day is about 150,000,000 cu. ft., costing about $120,000, of which amount $40,000 was necessary to pay for the excess due to fog.

THE CRUDE PETROLEUM PRODUCT OF PENNSYLVANIA in 1897 was 34,724,700 barrels, an increase of 1,279,129 barrels over the production of 1896. The total Ohio production of 1897 was 19,547,514 barrels; a decrease of 3,764,339 barrels from the previous year. The total deliveries during 1897 amounted to 53,713,484 barrels; an increase of 4,414,872 barrels over 1896. The total stock in possession of the pipe lines at the close of 1897 was 33,552,431 barrels, or about eight months' supply.

ANNUAL MEETING OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

The fourth annual meeting of this Society was held this week at the house of the American Society of Mechanical Engineers, in New York city. The opening session on Tuesday morning, Jan. 25, was devoted to general business. An address was read by the retiring President, Mr. W. M. Mackay. He said that the Society had increased in membership about 25% during the year, the total number of members and associates now being 142. His address related chiefly to methods of increasing the Society's growth and influence. Reports of the Secretary, Treasurer, Board of Managers, and Council followed, showing a generally satisfactory condition of the Society and suggesting a few changes in its methods. The committee on compulsory state legislation concerning the ventilation of schools and other public buildings, reported that bills had been introduced in the legislatures of New York, New Jersey and Pennsylvania relating to the subject. There was a prospect of the bills obtaining consideration in the legislatures of New York and New Jersey, but in Pennsylvania the bill had been introduced too late to be considered at the present session.

The committee on uniform contract and specifications reported that it was about to have a conference with the Association of Master Steam Fitters, and its final report would be delayed. The committee on standards for heating and ventilation reported that it had been trying to collect statistics from the school boards of different cities concerning the kind of systems of heating and ventilation used, the number of cubic feet of air supplied per pupil per hour, etc. The result was disappointing, replies being received from only 34 out of the 165 cities and towns from which replies were requested. Only eleven out of the 34 towns used the fan system of ventilation. The air supplied per person per hour was 1,800 cu. ft. in the majority of the replies; others reporting various amounts from 1,200 to 2,500. The space allowed per pupil ranged from 175 to 250 cu. ft., a few replies only being outside of this range. The floor space per pupil was in most cases from 15 to 20 sq. ft., about one-third of the replies giving less than 15. The maximum number of children in a room varied generally from 40 to 60, a few replies giving from 60 to 80.

After the presentation of these reports new business was taken up. Strong criticisms were made by some of the members concerning the editing of the "Transactions" of the Society, some finding fault because the debates had not been properly reviewed and put in better literary style, and others because some of the proceedings of the midsummer meeting had been left out entirely. The Council, which is the body responsible for the publications, was defended from the latter attack, and it was stated that the proceedings referred to were a discussion of a patent electric heating device, which was properly expunged from the printed transactions because no data had been given by the promoters of the device from which any engineer could calculate its capacity. Several amendments to the constitution which had been proposed at a previous meeting were voted upon affirmatively. The morning session then adjourned. The remaining sessions will be devoted to the presentation and discussion of professional papers and topics, an account of which will be given in our next issue.

ANNUAL MEETING OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The forty-fifth annual meeting of this Society was held at its house in New York city, on Jan. 19 and 20. The business meeting, on Jan. 19, was called to order at about 10:30 a. m., by President Benjamin M. Harrod, and, after the usual preliminaries, the reports of the Secretary and Board of Direction were read and passed upon. The substance of these reports is given below. Between 80 and 100 members were present at this session.

The announcement was made that the Norman medal had been awarded to the paper by Mr. Julius Baier on "Wind Pressure in the St. Louis Tornado, with Special Reference to the Necessity of Wind Bracing for High Buildings," and

that the Rowland prize had been awarded to the paper on "The Astoria City Water-Works," by Mr. Arthur L. Adams.

Under the head of new business a number of resolutions urging the appointment of special committees and making changes in the present practice of the Society were discussed and voted upon. Upon the motion of Col. H. G. Prout, it was voted that a committee should be appointed to investigate the subject of rail joints for steam railways, and recommend standards of practice for the consideration of the Society. A motion was also adopted to bind the remaining copies of the historical sketch of the Society, which number about 1,700, and place them on sale at such a price as would insure their rapid disposal, the money to be used toward paying off the debt on the Society's new house. Mr. James Owen presented a motion which provided that a committee should be appointed to investigate and report upon paints for structural iron-work. This motion was adopted after some discussion, in which the advisability of trying to settle on standards for a material about which so little is known, and the different brands of which were so entirely in the hands of rival establishments whose only purpose would be to secure the recommendation of their own brands to the exclusion of all others, was strongly questioned.

A lively discussion also took place upon the succeeding motion by Mr. Joseph M. Knapp to abandon the 1 to 24 o'clock notation of time now used in the proceedings, programmes, and announcements of the Society. Mr. Knapp urged that the attempt of the Society to promote this notation had been a failure, that it was not used by the members, and further than this, it was a matter of ridicule among them, and finally, that it was an annoyance to everyone who had to use the system even to the limited extent of deciphering the Society's announcements. A number of other members supported Mr. Knapp's statements, but the change was strongly opposed by Messrs. Geo. S. Morison, Mendes Cohen, Francis Collingwood and a number of the older members, on the basis that a recommendation once formally adopted by the Society as a whole could not justly be annulled by a small portion of the members. This brought out the fact that the records of the proceedings of the Society did not show anywhere in what manner the 24-oclock notation had come to be adopted by the Society. After several amendments had been made to the original motion, it was put to vote and lost.

Mr. W. W. Crehore, after stating that the Department of Public Parks of New York had recently employed a firm of architects hitherto unidentified with bridge construction, to prepare plans and specifications for the Lenox Ave. bridge over the Harlem River, offered a resolution that "the American Society of Civil Engineers hereby record its disapprobation of said recent action of the Department of Parks, and protest against the selection by public officials of a person or persons outside the engineering profession to design and prepare plans for a distinctly engineering work of such importance and magnitude as the bridge mentioned." The resolution was tabled without discussion. The same action was taken upon a resolution offered by Mr. Geo. H. Thomson, which was to the effect that in the absence of legal protection against unscrupulous persons who may advertise themselves as engineers, the Society go on record as "favoring judicious legal restrictions against the unauthorized use of the term."

The report of the tellers which followed showed that the following officers had been elected for the ensuing year: President, Alphonse Fteley, of New York; Vice-Presidents, Edward P. North, of New York, and Frederick P. Stearns, of Boston, Mass.; Treasurer, John Thomson, of New York; Directors: S. L. F. Deyo, of New York; John Kennedy, of Montreal, P. Q.; Henry Manley, of Boston, Mass.; C. C. Schneider, Pencoyd, Pa.; J. J. McVean, Grand Rapids, Mich., and Geo. Y. Wisner, of Detroit, Mich.

The installation of the new president was followed by luncheon, and then the members of the Society divided into three excursion parties for the afternoon. The first of the three visited the new Jerome Park reservoir of the Croton Water-Works under the guidance of Mr. Alphonse Fteley, Chief Engineer, and Mr. Alfred Craven, Division Engineer. Excursion No. 2 was to the Bowling Greene Building and other large office buildings in the business district, and was conducted by Mr. R. P. Bolton. The third excursion party visited the new buildings of Columbia University, and was conducted by Prof. Wm. H. Burr. In the evening a reception was held at the rooms of the new Society house.

The second day of the convention was to have been devoted to an excursion by boat on the North and East rivers, but the prevailing dense fog prevented. In the evening an address on the "New Relations Between Engineering and Architecture" was delivered by Mr. Russell Sturgis at the Society house.

The net increase during the year has been 58. The total number of applications received during the year was 176. Action has been taken as follows:

Passed to ballot as Members	60
Passed to ballot as Associate Members	51
Elected Associates	4
Elected Juniors	36
Applications now awaiting action	57
Total	176

The losses by death during the year number 17. They are as follows: Two Honorary Members—James C. Duane, William Ezra Worthen. Twelve Members—Charles Benjamin Brush, Thomas Doane, Albert Fink, Thomas Davis Lovett, George Edward Mann, Silvanus Miller, Gouverneur Morris, Edwin Green Nourse, Francis Ensor Prendergast, Mirtiliano Sicard, Isaac Williams Smith, Joseph Veazie. One Associate Member—Frederick Beecher Lawton. One Junior—Henry Clay Yeatman. One Subscriber—John H. Drake.

Library.—The following sums have been expended upon the library during the year:

Binding 25 volumes	$52.30	
Purchase of books	26.00	
		$78.30
Total of previous year		70.60

The additions to the library from all sources have been:

Bound volumes	323
Unbound volumes	387
Pamphlets	172
Maps, photographs and charts	176
Specifications	122
	1,180
The present number of title in library is	21,921

Heretofore the Board has emphasized the dependence of the growth of the library upon legacies and contributions of engineering literature from members, as well as from others interested in the advancement of the objects for which the Society is organized. Under the conditions which obtained in the old house, which was not fireproof, and which afforded neither the necessary room for expansion nor adequate facilities for those who desired to use the books, it was recognized that to bring the library up to date was practically impossible. Under these conditions, as can be seen by reference to previous annual reports, very little money has been expended in the purchase of new books.

The Board believes that the time has come when the Society has abundant ability to acquire by purchase such of the more modern works of engineering interest as it is not possible to secure by gift, and that in the near future the shelving should be supplied with copies of all volumes for which there is demand. It is hoped that the new conditions will induce donations from authors and publishers of technical works, many of whom are connected with the Society, which will result in large and valuable additions to the library. In this connection attention is called to the shelf-room provided in the new house. As stated above, the total number of titles in the library is 21,921, estimated as occupying a space equivalent to 15,000 volumes, while the stacks already erected have capacity for 50,000 volumes, which capacity may at any time be doubled by the erection of another tier of stacks. During the year, through the bequest of the late Wm. E. Worthen, Past President and Honorary Member, 239 titles, representing 444 volumes, were added to the library.

Society House.—The Society house, for which ground was broken on July 9, 1896, was formally opened on Nov. 24, 1897. The estimated cost of $90,000, given in the annual report for the year 1895, and incorporated later in the conditions for the architectural competition, proved correct. It was found possible to execute a general contract for the building, together with the cost of excavating the lots, for the sum of $91,275.

In addition to this, however, the vault privilege was purchased from the city; the metal book stacks, the bookcases and the book-lift were secured with a view to the ultimate extension of the library. The gas and electric light fixtures, the furniture, decorations and hangings were arranged for so that it was possible to turn over to the members on the day of opening, a house complete in detail, and harmonious in its entirety. Slight alterations and additions affecting the general contract were made as the work progressed, but all these it is believed were necessary and desirable.

While a final settlement of the contract has not yet been made, the Board is now confident that the permanent loan will be fixed at not more that $90,000. As has been heretofore reported, the estimated value of the 23d St. house proved to be a correct one, the price received being $60,000 cash. Since Dec. 16, 1897, the house has been open every day between the hours of 9 and 22, except on Sundays, when it has been open from 14 to 19 o'clock. The record of attendance is being kept in detail, and it is hoped that the use of the library, as well as of the lounging and conversation room, will so increase as to justify the additional expense incurred.

An edition of 2,000 copies of the Society history was printed; 300 copies were bound in full morocco, of which 216 have been sold at $10 per copy. The total cost has been $1,216.94, and the net profit, $943.06.

Publications.—The following table gives in detail a summary of the publications issued during the year:

	Number Issued.	Number Total, each edition.	Number Of pages.	Plates.	Cuts
"Transactions"*	2	2,400	1,068	20	102
"Proceedings"	10	2,400	787	28	140
Constitution and List of Members	1	2,600	193	..	..
Advertisements	10	2,400	136	..	..
Reprints	2	300	60	2	..
Total	..	.....	2,244	48	332

*Includes Indexes and Table of Contents.

The cost of publications has been $7,374.20, as against $8,795.04, the net cost of publications for 1896. The following is a comparative table showing the cost of all publications, charges for time of employees excluded, for three years:

	1895.	1896.	1897.
Total pages published	2,008	2,471	2,244
Total cost	$9,745.03	$9,030.13	$8,054.72
Edition of "Transactions"	2,300	2,400	2,400
Edition of "Proceedings".	2,300	2,350	2,400
Average cost per page	$4.85	$3.65	$3.86

Meetings.—The annual meeting held in New York, Jan. 20 and 21, 1897, was attended by 279 members of the Society and a number of visitors. The attendance at the twenty-ninth annual convention, held in Quebec, Can., was 168 members and 158 guests. Eighteen semi-monthly meetings have been held at which the maximum attendance was 147, and the average 88. Twenty-one formal papers have been presented. In the oral discussion of these 72 persons took part, and correspondence from 132 persons was presented.

Medals and Prizes.—During the year the Board has, with the consent of the donors of the three prizes, adopted a new set of rules for their award. Heretofore each prize had been awarded by a separate committee appointed by the Board of Direction, and the change was made in order that one committee should consider the merits of every paper and recommend the awards of all prizes to the Board. The first award of prizes under this new rule will be made at this meeting.

Report of the Board of Direction.

Membership.—The changes in membership are shown in the following table:

	January 1, 1898.			During 1897.—Losses.				Adtns.
	Resident.	Non-resident.	Total.	By transfer.	Resignation.	Dropped.	Death.	Transfer.	Election.
Honorary members	2	7	9	..	..	..	2	..	2
Cor. members	..	3	3	..	..	..	..	..	..
Members	232	1,069	1,301	..	3	17	12	14	42
Associate	87	237	324	11	..	3	1	21	35
Associates	28	53	81	1	..	1	..	..	2
Juniors	110	180	290	23	9	8	1	..	35
Fellows	11	30	41	..	..	..	..	..	..
Subscribers	5	25	30	..	..	..	1	..	..
Total	475	1,604	2,079	35	12	29	17	35	116

[1] 11 Associate Members, 3 Juniors.
[2] 1 Associate, 20 Juniors.

Report of the Auditor.

Receipts.

Balance on hand Dec. 31, 1896		$11,455.88
Entrance fees	$2,885.00	
Current dues	20,942.80	
Past dues	1,013.00	
Advanced dues	5,286.78	
Certificates of membership	139.25	
Badges	525.25	
Sales of publications	2,162.96	
Advertisements	1,827.50	
Interest	810.00	
Compounding dues	250.00	
Miscellaneous	26.07	
Library (sale of duplicates)	2.65	
New Society house (subscriptions)	1,798.00	
Sale of securities	21,111.99	
Convention $509.00		
Annual meeting 836.00		
	1,344.00	
Loan, Mutual Life Insurance Co.	105,000.00	
Sale of No. 127 East 23d St.	60,000.00	
Sale of "Historical Sketch"	2,010.00	
Binding	684.26	
		$227,819.51
Total		$239,275.39

Disbursements.

General printing and stationery		$464.08
Publications		11,304.72
Postage		1,177.13
Library		1,585.63
Janitor		324.00
Badges		334.75
Contingencies		235.31
Gas and water		246.72
Finance—Books of account		1,218.32
House supplies—furniture		365.45
Certificates of membership		74.25
Fuel		120.00
Convention—Annual meeting		2,359.55
Insurance—Safe deposit		171.60
Norman medal—Rowland prize		171.05
Interest—Taxes		105.42
Current business		6,890.75
Repairs and betterments		46.15
"Historical Sketch"		1,006.94
Binding		472.95
House, 127 East 23d St.:		
Rent, 5 months 28 days at $250	$1,483.33	
Commission on sale	600.00	
Legal expenses	280.49	
Sundry expenses	30.42	
		2,394.24
New Society house:		
On contract, to b'lder and architect	$69,939.25	
Decorations and fixtures, book-lift, b'kcases, furniture, hangings, etc.	11,876.66	
Interest and taxes	4,536.38	
Legal expenses	417.18	
		86,769.47
Expenses of formal opening		1,402.60
Moving from 127 East 23d St. to new house		391.15
Cancellation of mortgages:		
Inslee mortgage	$30,000.00	
Eno mortgage	30,000.00	
Smith mortgage	11,500.00	
Guaranteeing title and legal expenses	522.75	
		72,022.75
Reduction of loan, Mutual Life Insurance Co.		35,000.00
Balance in Garfield National Bank	$10,497.97	
Trust company	267.44	
Hands of treasurer	985.00	
		11,750.41
Total		$239,275.39